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RESULTS OF A FIVE-YEAR CONTINUOUS APPLICATION OF FERTILIZER TO RICE GROWN IN CALUMPANG PADDY SOILS [1/]

A. A. BRIONES, J. G. DAVIDE, and N. L. GALVEZ [2/]

Continuous cropping of rice on a Calumpang paddy soil for a period of five years with and without the addition of fertilizers showed apparent differences in yield due to season. Consistently higher yields were obtained with Tjeremas during the dry than during the wet season but the reverse was true with the Milfor. Greater yields were obtained with Tjeremas than with Milfor over all seasons.

Under the conditions of the experiment, the yield responses of Tjeremas and Milfor indicated that 15 kg. N per hectare were sufficient to increase the yields. Rates beyond 15 kg. did not affect the yield significantly. No response to phosphorus or potassium was indicated.

At the rate of 30 kg. per hectare, nitrogen gave higher yields when applied at the surface than when mixed with the mud or applied in form of blocks into the reduced layer of the profile.

Chemical analyses of the soil indicated that after five years of cropping 35 per cent of the original organic matter content was lost. The pH of the soil increased. The available phosphorus level decreased with successive croppings except from plots where the soil was dug to a depth of 45 centimeters prior to cropping and fertilizer application. The concentration of the basic constituents Ca, Mg, and K, were increased by 1.43, 3.49, and 0.37 m.e./100 grams of soil, respectively.

Based on a survey of 814 farms in the Philippines (de los Reyes, 1958), the average yields of lowland rice were 44 and 39 cavans per hectare during the wet and dry seasons, respectively. However, large fluctuations in yields were observed and were attributed to the type of rice culture and variations in climatic conditions.

Nitrogen fertilizers are at present extensively used in rice production in the Philippines. The conditions in paddy rice culture and the nature of the soil and climate of the Philippines may highly favor the use of ammonium nitrogen over the nitrate form. Nitrate is known to be easily leached and denitrified in paddy soils.

Fertilizers are most commonly applied in lowland rice paddies by broadcast. Ashby (1952), Mears (1952), and Mitsui (1955),

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1/ Central Experiment Station Contribution No. 2819. Part of Project No. 671 and Rice and Corn Research Project No. 6.

2/ The authors are grateful to Mr. T. C. Cruz, who was responsible for the initial phase of this investigation; and to Dr. L. E. Nelson, former Cornell visiting professor of soils, for his technical advice.

however, have reported the advantage of deep placement of ammonium sulfate in the paddies over that of surface application. Deep placement reduced losses of nitrogen through denitrification and at the same time increased the utilization of the added nitrogen by the plants. A paddy soil profile consists of a surface oxidizing zone and a reducing zone immediately below the former. The idea in deep placement was to apply the nitrogen in the reducing zone. Ammonium nitrogen applied in this manner remains unchanged and is more available to the plant. De and Digar (1955), however, pointed out that placement of fertilizer at greater depth would probably deprive the shallow root system of a major portion of the nutrient added.

In the fertilization of rice, it is essential to know not only the amount and kind of fertilizer to be used but also the method of application. This study was conducted on a Calumpang paddy soil in the U.P. College of Agriculture Central Experiment Station from April, 1956, to January, 1961.

MATERIALS AND METHODS

The fertilizer treatments, replicated four times, were laid out in a randomized complete block design. Nitrogen, phosphorus, and potassium which were supplied as ammonium sulfate (20% N), superphosphate (20% P_2O_5), and muriate of potash (60% K_2O), respectively, were applied every cropping season. The treatments are described in table 1.

TABLE 1.—*The rates and methods of fertilizer application*

TREATMENT N—P_2O_5 —K_2O	METHOD OF APPLICATION
kg./ha.	
1. 0- 0- 0	No fertilizer added
2. 15- 0- 0 (M)	Mixed with mud
3. 30- 0- 0 (M)	" " "
4. 60- 0- 0 (M)	" " "
5. 30- 0- 0 (S)	Surface applied
6. 30- 0- 0 (B)	In blocks, 3 inches below surface
7. 30-30- 0 (M)	N and P applied as in Treatment 2
8. 30-30-30 (M)	N, P, and K as in Treatment 2
9. 30- 0- 0 (D)	N as in Treatment 2 but soil dug to 45 cm.

In treatments 2, 3, and 4, one-third of the nitrogen was worked with the mud during the last harrowing while in treatment 5, it was broadcast soon after planting. In these treatments, the remaining two-thirds of nitrogen was broadcast 20 days before boot-

ing.

The fertilizer blocks used in treatment 6 were prepared by mixing nine parts of soil and one part of ammonium sulfate in sufficient water to form a stiff paste, and spreading this out on a glass plate, cutting it into cubes and then allowing them to dry. The rate of application was one block between every four hills placed at a depth of three inches.

In treatments 7 and 8, phosphorus and potassium were all worked into the mud before planting. The soil in treatment 9 was first worked to a depth of 45 centimeters before nitrogen was applied in a manner similar to treatment 2.

Soil samples from the first 12-inch layer were collected from each plot at the start of the experiment (September, 1955) and at the end of the ninth cropping (February, 1961). The pH, organic matter and available phosphorus were determined according to Peech *et al.* (1947). Exchangeable calcium and magnesium were determined by titration with EDTA and potassium by the flame photometer method after their extraction from the soil with *N* ammonium acetate solution at pH 7.0.

The usual operations in preparing paddy soils were observed in all croppings, *viz.*, one plowing after complete submergence of the paddies for one week, followed by submergence for 3 to 5 days, and then a final plowing and subsequent harrowings prior to planting.

Milfor, an early-maturing rice variety known to be resistant to lodging, and Tjeremas, a medium-early maturing and lodging-susceptible variety, were used. Three to four seedlings were transplanted to each hill. The hills were spaced 40 centimeters between rows and 20 centimeters along the rows. The dates of planting and harvesting are given in table 2.

RESULTS AND DISCUSSION

Effect of season on yields. Tables 3 and 4 show the mean yields of grain of Milfor and Tjeremas as influenced by the different fertilizer treatments. The combined statistical analysis of the data for each variety indicated highly significant differences in yield between croppings. There were significant differences due to treatments in the 1959 dry season for Milfor and in the 1957 dry and 1960 wet seasons for Tjeremas. The coefficients of variation

TABLE 2.—*Dates of planting and harvesting of each variety*

CROPPING NUMBER	SEASON	VARIETY	PLANTING	HARVESTING
First	'56 Wet	Milfor	April 21, 1956	Sept. 27. 1956
		Tjeremas	—ditto—	—ditto—
Second	'57 Dry	Milfor	Jan. 7, 1957	April 24, 1957
		Tjeremas	—ditto—	May 7, 1957
Third	'57 Wet	Milfor	July 20, 1957	Nov. 25, 1957
		Tjeremas	July 16, 1957	—ditto—
Fourth	'58 Dry	Milfor	Feb. 6, 1958	June 18, 1958
		Tjeremas	Feb. 2, 1958	June 23, 1958
Fifth	'58 Wet	Milfor	July 25, 1958	Nov. 15, 1958
		Tjeremas	—ditto—	Nov. 23, 1958
Sixth	'59 Dry	Milfor	Dec. 12, 1958	March 24, 1959
		Tjeremas	—ditto—	March 23, 1959
Seventh	'59 Wet	Milfor	July 16, 1959	Oct. 29, 1959
		Tjeremas	July 15, 1959	Nov. 29, 1959
Eighth	'60 Dry	Milfor	Feb. 12, 1960	May 31, 1960
		Tjeremas	Jan. 26, 1960	June 17, 1960
Ninth	'60 Wet	Milfor	Sept. 27, 1960	Crop failed
		Tjeremas	—ditto—	Jan. 25. 1961

TABLE 3.—*Mean yields of Milfor as affected by different fertilizer treatments*

TREATMENT	'56 WET	'57 DRY	'57 WET	'58 DRY	'58 WET	'59 DRY	'59 WET	'60 DRY	
Kg./ha.				*c a v. / ha.*					
1. 0- 0- 0	88.1	45.5	75.0	49.0	48.8	56.2	42.5	56.2	57.7
2. 15- 0- 0 (M)	86.8	72.5	77.7	44.0	43.2	73.2	43.6	55.2	62.0
3. 30- 0- 0 (M)	83.7	72.5	74.0	48.4	53.1	70.7	40.3	54.0	62.1
4. 60- 0- 0 (M)	81.9	71.1	63.6	46.9	39.3	69.4	47.8	71.7	61.5
5. 30- 0- 0 (S)	83.2	67.0	85.5	50.4	a/	68.1	40.2	64.4	65.5
6. 30- 0- 0 (B)	87.4	60.9	64.7	46.9	51.2	75.4	46.5	64.0	62.1
7. 30-30- 0 (M)	83.0	53.9	63.5	52.2	51.7	60.9	43.5	62.1	58.8
8. 30-30-30 (M)	82.0	61.8	83.6	51.2	42.5	70.3	44.2	61.8	62.2
9. 30- 0- 0 (D)	87.0	73.5	82.8	49.1	a/	40.9	46.7	51.9	60.8
MEAN	84.1	64.3	74.5	48.7	47.1	65.0	43.9	60.1	61.0
LSD (.05)	NSb/	NS	NS	NS	NS	18.6	NS	NS	NS
C.V. (%)	15.9	27.7	18.2	21.8	29.3	19.6	16.3	14.0	—

a/ No data obtained due to severe damage.
b/ Not significant.

were rather high; this may account partly for the failure to detect in most cases yield differences between treatments. Yields of the unfertilized plot in most croppings were high.

TABLE 4.—*Mean yields of Tjeremas as affected by different fertilizer treatments*

TREATMENT	'56 WET	57 DRY	'57 WET	'58 DRY	'58 WET	'59 DRY	'59 WET	'60 DRY	'60 WET	MEAN
Kg./ha.					*cav./ha.*					
1. 0- 0- 0	72.7	99.5	78.0	70.6	60.6	82.0	24.3	73.9	57.2	71.6
2. 15- 0- 0 (M)	77.9	113.3	83.4	65.8	56.9	129.1	31.7	89.2	62.4	84.3
3. 30- 0- 0 (M)	84.3	118.2	93.8	70.6	56.7	113.3	25.5	82.1	74.1	84,0
4. 60- 0- 0 (M)	73.9	121.7	69.6	67.1	49.7	96.5	31.1	56.4	79.4	73.7
5. 30- 0- 0 (S)	84.0	113.7	80.5	80.6	a/	102.0	26.5	90.9	70.0	82.6
6. 30- 0- 0 (B)	77.6	120.5	73.2	73.4	42.0	88.1	29.8	73.1	69.7	76.5
7. 30-30- 0 (M)	62.4	122.8	58.9	56.8	58.5	99.0	23.0	59.7	74.8	68.9
8. 30-30-30 (M)	71.9	128.9	79.3	65.5	45.8	102.3	32.2	68.6	72.6	78.4
9. 30- 0- 0 (D)	75.1	84.7	91.9	70.2	a/	61.3	23.5	75.5	70.8	68.9
MEAN	75.5	113.7	78.7	68.9	52.9	97.1	24.8	74.4	70.1	76.5
LSD (.05)	NSb/	21.8	NS	NS	NS	NS	NS	NS	3.9	9.5
C.V. (%)	17.8	13.2	30.8	17.5	20.4	27.0	40.7	23.1	3.8	—

a/ No data obtained due to severe damage.
b/ Not significant.

Table 5 shows the effect of season on the yields of grain. The

TABLE 5.—*Comparison of yields between wet and dry seasons*

YEAR	DRY		WET	
	Milfor	Tjeremas	Milfor	Tjeremas
		Cav./ha.		
1956	—	—	84.1	75.5
1957	64.3	113.7	74.5	78.5
1958	48.7	68.9	47.1	52.9
1959	65.0	97.1	43.9	24.8
1960	60.1	74.4	—	70.1

yields for similar seasons fluctuate from year to year. This variation may be due to differences in climatic condition such as the frequency and intensity of rainfall and/or typhoon and in plant characteristics like lodging rather than due to differences in soil fertility. The combined statistical analysis indicated differences in yields between the wet and dry season croppings. The yields of Milfor, however, did not vary between the wet and dry seasons. But those of Tjeremas were constantly higher during the dry than during the wet seasons. Tjeremas is not resistant to lodging, but has a higher yield potential than Milfor. Yields of Milfor, in spite of its characteristic resistance to lodging, may be influenced by

its tillering characteristics. This variety tillers less than the Tjeremas. [3/] It will be recalled that the two varieties were planted at the same spacing.

Effect of different rates of nitrogen. The average yield responses to the different rates of nitrogen regardless of the method of placement are presented in table 6.

TABLE 6.—*Average yield of Milfor and Tjeremas as affected by rates of added nitrogen*

NITROGEN APPLIED	MILFOR		TJEREMAS	
	WET	DRY	WET	DRY
		Cav./ha.		
0	63.6	51.7	58.6	81.5
15	62.8	61.2	62.5	99.4
30	64.3	59.7	61.7	88.4
60	58.2	64.8	60.7	85.4

The data show that the 15 kg. N per hectare produced a maximum yield increase for both varieties. The yield increase was more in the dry than in the wet season. While yields between the wet and dry seasons as previously pointed out varied, yield increases tended to decline with increasing rate of nitrogen. This is especially true for Tjeremas. The yields of Milfor were not significantly affected by fertilization during the wet season.

Response to different methods of placements. The effect of the methods of application on the yields of the two rice varieties is shown in table 7. The data presented were obtained from the yields of plants receiving 30 kg. N per hectare.

TABLE 7.—*Average yields as affected by methods of placement of nitrogen fertilizer added at the rate of 30 kg. N per hectare*

	MILFOR		TJEREMAS	
	WET	DRY	WET	DRY
		Cav./ha.		
No fertilizer added	63.6	51.7	58.6	81.5
Mixed with mud	62.2	61.4	66.9	96.1
Broadcast on surface	69.6	62.5	65.3	96.8
As blocks at 3" deep	62.5	61.8	58.5	88.8
Mixed after digging soil to 45 cm.	70.1	53.9	65.3	72.9

It should be pointed out that the methods of placement differed only in the manner the initial one-third portion of nitrogen

3/ Personal communication with Dr. P. B. Escuro, Head, Department of Agronomy, U.P. College of Agriculture.

was applied. Except in the block-fertilizer application, the rest of the nitrogen was broadcast 20 days before the booting stage of the plants. In the block-fertilizer treatment, the second portion of the nitrogen was applied also in the form of blocks and placed three inches deep.

The data in table 7 reveal that yields of Milfor were not much affected by the different methods of placement. With Tjeremas, nitrogen, whether mixed with the mud or surface-applied was more effective than deep placement as fertilizer blocks. The low yield due to deep placement may be attributed to the positional unavailability of the nutrient, a block having been placed between every four hills. Since Tjeremas has a great tillering capacity, it is also possible that the rate of nitrogen applied was not adequate.

Working the soil to a depth of 45 centimeters during land preparation may render the added nitrogen less effective especially with a lodging and better tillering variety. This may be due to the dilution of the fertility of the soil.

Effects on Soil Fertility Level

The chemical analysis of the soil collected at the start of the experiment and after the ninth cropping is given in table 8.

The organic matter contents of the soil generally decreased after five years of cropping even with fertilizer application. Losses of organic matter averaged 35 per cent of the original organic matter level. The loss of organic matter was lower where higher rates of nitrogen were applied.

The pH of the soil showed slight increase after five years of cropping. There was an average increase of 0.64 pH unit. It should be pointed out that the soil prior to this experiment was under better drained conditions. After prolonged submergence with alternate drainage of the soil in the course of cropping, the degree of reduction in the soil was increased. This may be one of the causes attributing to the slight change in pH.

The levels of available soil phosphorus were also found to decrease. Similar results were obtained by Mercado [4/], Lusterio [5/],

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4/ A. Mercado Jr., "The effect of algae on the growth of lowland rice". Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, U.P. April, 1958. Unpublished.

5/ F. G. Lusterio, "A preliminary study on the effects of alternate and complete submergence of upland soil on soil properties and crop yield". Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, U.P. April, 1958. Unpublished.

TABLE 8.—*Chemical analyses of samples from the first 12-inch layer of the soil before and after five years of continuous croppings and fertilization*

TREATMENT	O.M.		pH		Available P		Ca		Mg		K	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Kg./ha.	*per cent*				*ppm.*		*m.e./100 g.*		*m.e./100 g.*		*m.e./100 g.*	
1. 0- 0- 0	2.50	1.65	6.00	6.60	2.65	1.60	16.97	18.24	9.70	11.95	0.17	0.43
2. 15- 0- 0	2.65	1.56	6.09	6.80	2.84	0.60	17.32	19.02	9.50	12.50	0.15	0.53
3. 30- 0- 0	2.56	1.76	6.11	6.76	2.87	1.47	17.33	18.34	9.34	12.67	0.13	0.46
4. 60- 0- 0	2.68	1.90	6.13	6.60	2.70	1.20	17.18	17.98	8.35	12.21	0.13	0.54
5. 30-30- 0	2.73	1.99	6.06	6.85	2.79	1.60	16.82	18.88	9.23	12.97	0.10	0.55
6. 30-30-30	2.75	1.54	6.06	6.63	3.21	3.00	16.63	18.70	7.08	12.34	0.12	0.38
7. 30- 0- 0a/	2.45	1.44	6.05	6.70	2.50	4.30	16.69	17.80	10.30	13.26	0.11	0.61
MEAN	2.62	1.69	6.07	6.71	2.79	1.97	16.99	18.42	9.07	12.56	0.13	0.50

a/ Soil worked to 45 cm. deep

and Mendoza [6/] in soils subjected to prolonged submergence.

A striking increase in the content of available phosphorus was noted in the plots dug to 45 centimeters. Higher contents of the phosphorus in the lower layer could have been brought up by the process of digging and mixing.

The exchangeable calcium, magnesium, and potassium showed increases in concentration from their original exchangeable levels. The increases in concentration of these basic constituents in the soil are given in table 9. The average increases were 1.43, 3.49 and 0.37 m.e./100 grams of soil for calcium, magnesium, and potassium, respectively.

TABLE 9.—*Average increase in the concentration of exchangeable bases after five years of cropping*

TREATMENT	CALCIUM	MAGNESIUM	POTASSIUM
		m.e./100	
1. 0- 0- 0	1.27	2.25	0.26
2. 15- 0- 0	1.70	3.00	0.38
3. 30- 0- 0	1.01	3.33	0.33
4. 60- 0- 0	0.80	3.86	0.41
5. 30-30- 0	2.06	3.74	0.45
6. 30-30-30	2.07	5.26	0.26
7. 30- 0- 0 a/	1.11	2.96	0.50

a/ Soil worked to 45 cm. deep.

As the rate of nitrogen application was increased, the increase in concentration of calcium was correspondingly lowered. The highest increase in calcium was in treatments receiving superphosphate. The calcium content in this material must have contributed to the observed increase. Between treatments receiving 30 kg. nitrogen alone, the calcium content of the soil did not vary much.

The trend in the increase of the concentration of exchangeable magnesium in the soil closely parallel that of calcium.

No consistent trend was shown with regards to the increases in the concentration of potassium. The addition of 30 kg. K_2O for five years did not change the level of exchangeable K in the soil.

It may be possible that nutrient losses through leaching under

6/ S. P. Mendoza Jr., "Studies on the effect of puddling paddy soil. I. Availability of phosphorus in the soil planted to rice". Thesis presented for graduation with the degree of Bachelor of Science in Agriculture from the College of Agriculture, U.P. April, 1958. Unpublished.

field conditions will not be a serious deterrent to the growth of paddy rice plants because of the presence of a hard pan impeding this process. The nutrients would therefore be beyond the roots of the plants temporarily since after repeated deep tillage in the course of land preparation, the positionally unavailable nutrients are brought back to the surface layer. This might have happened with respect to the increased concentration of the bases studied. The irrigation water used to maintain the paddy condition was found to contain on the average 40.9, 26.3, and 10.9 parts per million, of calcium, magnesium and potassium 7/, respectively. Also an earlier study (Reyes, *et al.*, 1961) showed that percolates collected from lysimeters grown to paddy rice contained magnesium in greatest concentration with calcium closely following. Potassium was found in low concentration in the percolates. Therefore it appears that accumulation of these nutrients may possibly be due to the irrigation water used during successive croppings. The increase in the concentrations of the bases may also help explain the increase in pH of the soil.

7/ N. L. Galvez, and G. V. Simsiman, "Quality of irrigation water". Paper read before the Rice and Corn Seminar on March 6, 1961.

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LYSIMETER STUDIES ON A LIPA CLAY LOAM GROWN TO PADDY RICE
II. EFFECTS OF FERTILIZATION ON GRAIN YIELDS [1/]

EDILBERTO D. REYES and NICOLAS L. GALVEZ

Yields of grain from the big lysimeters in the wet seasons were higher than in the corresponding dry seasons. Yields between similar seasons showed a tendency to decrease with successive croppings. On the other hand, the mean yields of the wet and dry season crops on the small tanks were similar and tended to increase with succeeding croppings. The applications of nitrogen effected significant increases in the yields from both the big and small lysimeters. Grain yields were not significantly affected by the rates of percolation, by the additions of iron, either as the chelate or the chloride, or by the addition of manganous sulfate.

In the small tanks, the applications of organic matter at the rates of 10 and 20 tons per hectare significantly increased yields by 11 and 27 per cent, respectively. Ammonium hydroxide, which was applied with the irrigation water, and urea were found to be less effective than ammonium sulfate as sources of nitrogen.

Yields from the big lysimeters were comparatively much higher than those from the small lysimeters. However, a comparison of the relative increases in yields from both big and small lysimeters suggests that greater returns from nitrogen applications would be expected from shallow than from deep paddy soils.

Agricultural researchers are exploring new ways and means of increasing the production and improving the quality of field crops, especially rice which is the staple food of about 70 per cent of the world's population. That the application of fertilizers increases rice yields is now widely recognized but the efficiency of utilization of added nutrients by the rice plants remains to be studied.

One of the basic tools for investigating the effect of added nutrients in the soil is the lysimeter. The value of lysimeters in soil fertility investigations has been aptly demonstrated by Jones (1942), Kardos (1948), Stauffer and Rust (1954), and Dreibelbiss and McGuiness (1957). The use of lysimeters to study leaching losses under submerged conditions and the effect of fertilizers on crop yields would provide useful information in assessing the productivity status of the soils and in formulating fertilizer recommendations for rice.

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MATERIALS AND METHODS

The description and set-up of the lysimeters as well as the operations on the big lysimeters were presented in an earlier paper (Reyes, *et al.*, 1961). The operations on the small lysimeters with slight modifications were similar to those on the big lysimeters.

Twenty-four big and 36 small "filled-in" lysimeters were used during the four cropping periods reported herein. These tanks correspondingly accommodated 8 and 12 treatments (tables 1 and 2) laid out in a completely randomized design. At the time of

TABLE 1.—*Yields of grain of* Milfor *6* (2) *from the big lysimeters in four seasons*

TREATMENT		SEASON				
Fertilizers [a/]	Percolation rate	'55 Wet	'55 Dry	'56 Wet	'56 Dry	Mean
	Inch/week	*Grams per tank*				
0- 0-0	¼	431	326	342	263	341
0-45-0	¼	451	401	344	292	372
60-45-0	0	548	360	357	364	407
60-45-0	¼	487	378	413	346	406
60-45-0	1	490	411	333	367	400
60-45-0 plus 5 ppm Fe (Fe as Ferric chloride)	¼	499	395	420	376[b/]	423
60-45-0 plus 5 ppm Fe (Fe as Iron chelate)	¼	511	412	365	371	415
60-45-0 plus 5 ppm Mn (Mn as Manganous sulfate)	¼	469	422	403	358	413
Mean		486	388	370	342	397
LSD at 5% level		64	52	64	46	

[a/] Indicated rates are in kg. of N, available P_2O_5 and water-soluble K_2O per hectare.

[b/] Based on 2 observations.

the first planting, each big lysimeter containing 255 kg. of air-dry Lipa clay loam had a column of soil about 43 cm. thick, while each small tank, containing 50 kg. of the soil had a soil column of about 18 cm.

One-third of the nitrogen rate and all of the phosphorus and the micronutrients, iron and manganese, as well as the composted water hyacinth (for the small tanks) were applied immediately before every planting. These were thoroughly mixed with the first six inches of the soil. The second and last one-third portions of inorganic nitrogen fertilizers were applied at the tillering and

TABLE 2.—*Yields of grain of Milfor 6 (2) from the four croppings on the small lysimeters*

TREATMENT		SEASON				
Fertilizers [a]	Percolation rate	'55 Wet	'55 Dry	'56 Wet	'56 Dry	Mean
	Inch/week	*Grams per tank*				
0- 0-0	¼	67	61	96	55	70
0-45-0	¼	63	74	100	95	83
60-45-0	0	103	103	123	122	113
60-45-0	¼	96	100	120	130	112
60-45-0	1	103	92	130	139	116
60-45-0 plus 5 ppm. Fe (Fe as Ferric chloride)	¼	104	106	125	133	117
60-45-0 plus 5 ppm. Fe (Fe as Iron chelate)	¼	91	100	111	144	112
60-45-0 plus 5 ppm. Mn (Mn as Manganese sulfate)	¼	94	101	125	134	114
60-45-0 plus 10 tons O.M. [b]	¼	125	114	146	113	125
60-45-0 plus 20 tons O.M. [c]	¼	131	122	169	145	142
60-45-0 (N as urea)	¼	87	89	99	133	102
60-45-0 (N as ammonium hydroxide)	¼	72	76	121	103	93
Mean		95	95	123	121	108
L.S.D. at the 5% level		29	18	20	31	11

[a] Indicated rates are in kg. of total N, available P_2O_5, and water-soluble K_2O per hectare. Unless otherwise specified, source of N was ammonium sulfate (20% N.)

[b] 15 tons of organic matter per hectare in the '55 crop.

[c] 30 tons of organic matter per hectare in the '55 wet crop.

booting stages of the plants, respectively. "Dapog"-grown seedlings of Milfor 6 (2) were planted in both big and small lysimeters. Seven hills were maintained in each big tank while only four were made in each small tank. These hills were spaced about 25 cm. from each other with two seedlings to a hill. The volume of the percolating water drawn daily from each big tank subjected to 1/4 inch percolation per week amounted to 414 ml., while from each similarly leached small tank, it was 234 ml.

The dates of planting and harvesting for the four croppings in both big and small lysimeters are given below:

Cropping Number	*Season*	*Date of Planting*	*Date of Harvesting*
First	1955 Wet	July 5, 1955	October 24, 1955
Second	1955 Dry	December 5, 1955	March 26, 1956
Third	1956 Wet	July 14, 1956	November 6, 1956
Fourth	1956 Dry	December 12, 1956	April 10, 1957

Statistical analyses of the data were made according to Cochran and Cox (1953).

RESULTS AND DISCUSSION

Yields of grain from the big lysimeters. The mean yields from the big tanks and the combined statistical analysis of the yield data are presented in tables 1 and 3, respectively.

TABLE 3.—*Combined statistical analysis of the yields of grain from the big lysimeters*

SOURCE OF VARIATION	DEGREES OF FREEDOM	MEAN SQUARE
Seasons	3	93,364.9 b/
Wet vs. dry seasons	1	97,470.1 b/
Within 2 wet seasons	1	157,002.4 b/
Within 2 dry seasons	1	25,622.5 b/
Treatments	7	8,933.2 b/
No N vs. N treatments	1	53,020.2 b/
Among N treatments	6	1,585.4
Treatments x Seasons	21	2,187.7 a/
Treatments x wet vs. dry seasons	7	2,333.1 a/
Treatments x within 2 wet seasons	7	2,542.0 a/
Treatments x within 2 dry seasons	7	1,688.0
Error	63	1,075.3
Total	94	

a/ Significant at the 5% level.
b/ Significant at the 1% level.

There were marked differences in yields during the wet and dry seasons. Except in a few treatments, yields in the wet seasons were higher than in the corresponding dry seasons. Yields between similar seasons tended to decrease with the croppings most probably as a result of the lowering of the fertility of the soil.

The significant responses of the plants to nitrogen applications as reflected by the marked increase in the yields of grain could be regarded as good indications of nitrogen deficiency in the soils before cropping. The need for applying nitrogen every cropping is, therefore, highly suggested.

The plants did not respond significantly to added phosphorus fertilizers over all four croppings. However, a response to phosphorus was observed in the 1955 dry season crop. It should be mentioned that during the first cropping, there was profuse growth of algae in most of the phosphorus-treated tanks. It seems that the response of plants to phosphorus addition in the 1955 dry

season crop may have been influenced indirectly by the presence of algae.

The different rates of percolation did not significantly affect yields. Also, the effect of the rates of percolation was not consistent between seasons. Under the conditions of the experiment, it is believed that the different rates of percolation employed could not have as yet caused substantial losses of nutrients as to affect crop responses to the added fertilizers. However, the continued percolation of water would gradually influence future yields due to the differential leaching losses of plant nutrients from the soils. This may partly account for the tendency of yields to decrease with cropping on similar seasons (table 1).

Crop yields were not significantly affected by the addition of iron and manganese. The applications of iron, either in the form of chelate or chloride, and manganous sulfate to improve yields, therefore, were not warranted under the conditions of the experiments.

A breakdown of the *treatments x seasons* interaction indicated that yield responses were consistent only during the dry seasons (table 3). The unpredictable weather conditions, such as the intensity and frequency of rainfall, along with the possible addition of nutrients, such as nitrogen, through the rain water (Venema, 1961) and through nitrogen-fixation by soil microorganisms most likely had affected the responses of the wet season crops.

Yields of grain from the small lysimeters. The mean yields of grain from the small lysimeters and the combined statistical analysis of the yield data are reported in tables 2 and 4, respectively.

TABLE 4.—*Combined statistical analysis of the yields of grain from the small lysimeters*

SOURCE OF VARIATION	DEGREES OF FREEDOM	MEAN SQUARE
Seasons	3	8,331.8 a/
Wet vs. dry seasons	1	1.1
Within 2 wet seasons	1	13,136.4 a/
Within 2 dry seasons	1	11,857.9 a/
Treatments	11	4,444.3 a/
Treatments x Seasons	33	340.0
Error	90	213.9
Pooled Error	123	247.6
Total	137	

a/ Significant at the 1 per cent level.

The yields during the wet and dry seasons of each cropping year were similar, but were comparatively higher in the second than in the first year (table 2). The combined statistical analysis of the data indicated that there was no significant difference in yields between the wet and dry season crops (table 4). The highly significant effect of treatments and the absence of a significant *treatments x seasons* interaction would indicate that the responses to treatments were relatively consistent from one season to another.

The data also reveal a highly significant response of the plants to the additions of nitrogen. The growth of plants on unfertilized Lipa clay loam during all four croppings, in other words, was limited by a deficiency of available nitrogen in the soil.

The combined statistical analysis showed a significant effect of phosphorus applications on grain yields. Within individual seasons, however, only in the 1956 dry season was a significant response to phosphorus application obtained. The indicated response, therefore, may be attributed to either the effects of a gradual accumulation of phosphorus fertilizers in th soil or to the stimulating effect of added phosphorus on algal growth. Algae may indirectly have effected the improvement of the grain yields possibly through fixation of nitrogen.

As in the case of the big lysimeters, the rates of percolation of water did not affect yields significantly. Likewise, the results indicated that Lipa clay loam is adequately supplied with the micronutrients, iron and manganese, to meet the requirements of rice.

The applications of 10 and 20 tons of decomposed water hyacinth per hectare in addition to the inorganic nitrogen and phosphorus fertilizers resulted in significant yield increases of 11 and 27 per cent, respectively. This would rather imply that the addition of a mixture of inorganic fertilizers and compost may be more efficient in promoting yields than the addition of readily-available inorganic fertilizers only. However, the significant yield increases may have been due to the high amount of nutrients added through organic matter, although only a relatively small amount of the added nutrients, especially nitrogen and phosphorus, would be readily available for plant use.

Ammonium hydroxide, which was applied with the flood water, and urea were observed to be less effective sources of nitrogen than ammonium sulfate. The surface application of ammonium hydro-

xide resulted in the lowest mean yield compared to those due to the other nitrogen sources (table 2).

Plant response to added nitrogen on big and small lysimeters. The comparative response of Milfor 6 (2) to nitrogen applications when grown on the same soils of different depths is presented in table 5. The figures were derived from yields of the big and small lysimeters subjected to the same treatments.

TABLE 5.—*Response of Milfor 6* (2) *to nitrogen application on big and small lysimeters*

TREATMENT	WET SEASON			DRY SEASON		
	'55	'56	Mean	'55	'56	Mean
	Cavans per hectare a/					
Big lysimeter						
No nitrogen	220	171	196	181	139	160
With nitrogen	250	190	220	197	181	189
Mean	242	185	214	193	170	182
Small lysimeter						
No nitrogen	73	109	91	75	84	80
With nitrogen	110	136	123	112	149	130
Mean	101	129	115	103	133	118

a/ Grain yield in grams per tank multiplied by the conversion factors, 0.498 and 1.114, for the big and small lysimeters, respectively.

Yields from the big lysimeters were consistently much greater compared to those from the small lysimeters. The average yield from the big tank was equivalent to 198 cavans per hectare, while that from the small tanks was equivalent to 116 cavans per hectare. The marked difference is attributable to the volume of soil which the roots of plants could exploit for nutrients and which was much greater in the big than in the small tanks. Also, the roots in the former were not as restricted as those in the latter.

On the average, increases due to nitrogen from both big and small lysimeters were greater during the dry than during the wet season. It is well known that available forms of nitrogen are added to soils by way of rain water. According to Venema (1961), the highest amounts of total nitrogen brought down by tropical rains are generally observable whenever a period of drought is followed by heavy rainfall. After the dry season, large amounts of nitrogen could have been added to the soils through the rain at the start of the wet season croppings. Rice plants, therefore, would have more

nitrogen for their use during the wet than during the dry seasons. Apparently, the plants could have favorably responded to nitrogen applications at rates higher than 60 kg. of nitrogen per hectare during the dry seasons. The effects of the differences in weather conditions during the wet and dry seasons, however, should not be overlooked.

Yield increases due to nitrogen application were evidently much more in the small than in the big tanks. This would emphasize that higher returns per kilogram of nitrogen would be obtained from plants grown on shallow than on deep soils.

It should be recalled that yields from the big tanks tended to decrease with the croppings on similar seasons in contrast to the trend of results observed in the small tanks. Further, although plant responses in both big and small lysimeters were significantly affected by nitrogen applications, the responses between croppings were more consistent in the small than in the big tanks. The contrasting performance of the plants must have been influenced by the relative ease with which shallow and deep soils attain equilibrium condition, particularly as regards soil nitrogen balance, with the transition from well-drained to poorly-drained conditions of the soils. According to Ensminger and Pearson (1950), there exists in soils an equilibrium between the addition of organic matter by vegetation and its decomposition by microorganisms under natural conditions, which, particularly for soil nitrogen, is determined largely by climatic conditions but may be modified by changes in farm management practices.

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COMPARATIVE EFFICIENCY OF STARTER RATIONS FOR EARLY WEANED PIGS [1/]

J. A. EUSEBIO, R. D. PUYAOAN, and G. D. LORENZANA [2/]

WITH ONE TEXT FIGURE

Three experiments, using 24 litters (involving 193 pigs), were conducted. In experiment I, the efficiency of eight starter rations for early weaned baby pigs were compared with each other. In experiment II, the best starter ration in experiment I was compared to two starter rations with 10 and 20 per cent skim milk. In experiment III, the pigs raised in the conventional method, that is, letting them stay with the sow until their eight week, was compared to all the early weaned pigs in experiment I fed the 8 starter rations. In the starter ration with skim milk, the 10 per cent level produced higher gain than the 20 per cent level but in feed conversion efficiency, the reverse was noted. Both of the rations in experiment II (with skim milk) were superior to the best ration in experiment I in gain in weight; however the differences among these treatments were not statistically significant. In experiment III, except in the pigs fed with two starter rations (18 per cent protein without afsillin and 20 per cent protein with antibiotics) the early weaned baby pigs had higher gains in weight than those allowed to suck from the lactating sow up to 56 days. The difference in gain in weight between the naturally weaned pigs and the baby pigs fed with the best starter ration in experiment I was significant (H.S.D. — 5.02 at 5 per cent).

Considerable studies on early weaning of pigs have been done abroad during the past 10 years. Feed formulas have been worked out to wean pigs as early as 7-10 days of age (Neisheim and Krider, 1950; Catron *et al.*, 1953; Crampton, 1953; Teague, 1954; Speer *et al.*, 1954; Jensen *et al.*, 1960; and Peo and Hudson, 1960), thus allowing a sow to farrow 5 to 6 times in two years instead of the maximum of twice a year. Weaning at this age has other advantages: It produces heavier pigs with fewer runts in eight weeks, makes pigs eat rations earlier, controls better the nutritional anemia and scours among pigs, lowers the sow feed cost, requires less housing space, saves more pigs from crushing by the sow, and reduces the possibilities of transferring disease from the sow to the litter.

In the Philippines, however, the primary problems are (1) how to compound a starter ration that will meet the nutritional

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and health requirements of baby pigs and, (2) how to determine the best time and method of weaning and managing the baby pigs.

This study compares the efficiency of different formulas of starter rations for early weaning pigs using the locally available feedstuffs and shows the effect of feed supplementation (Afsillin Swine) in varying levels of protein and fiber (binlid) contents in the rations.

MATERIALS AND METHODS

All the sows used had, before the experiment, more or less the same age and health conditions, and were, during their gestation period, fed in confinement. It was also seen to it that all the litters used came from naturally bred sows.

In a preliminary experiment, Berkshire and Duroc litters weaned at the age of 30 days were given preliminary feeding using starter ration II (table 1). Based on the results of this experiment, the other seven starter rations were compounded.

TABLE 1.—*Composition and chemical analysis of starter rations*

INGREDIENTS	PARTS BY WEIGHT							
	I	II	III	IV	V	VI	VII	VIII
Ground yellow corn	55	55	51	51	55	55	51	51
Rice bran	20	20	20	20	10	10	10	10
Binlid	—	—	—	—	10	10	10	10
Fish Meal	11	11	13	13	11	11	13	13
Soybean oil meal	11	11	13	13	11	11	13	13
Molasses	3	3	3	3	3	3	3	3
Salt (Per cent)	1	1	1	1	1	1	1	1
Oyster shell (Per cent)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Afsillin (Per cent):	—	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TOTAL	100	100	100	100	100	100	100	100
Calculated Analysis								
					Per cent			
Protein	18.61	18.70	20.62	20.71	18.48	18.57	20.49	20.58
Fat	5.71	5.72	3.11	3.12	6.80	6.81	4.26	4.27
Fiber	4.44	4.54	5.36	5.46	3.04	3.14	4.09	4.10
Calcium	.99	.99	1.09	1.09	.99	.99	1.09	1.09
Phosphorus	.81	.81	.87	.87	.72	.72	.84	.84

Experiment I. Sixteen litters of the Berkjala x Berkshire x Berkshire and Berkjala x Berkshire x Duroc crosses consisting of 130 baby pigs weaned at the age of 30 days were alloted at random

within litter in a 2^3 factorial arrangement. The two crossbreeds served as the replications. The eight ration variables consisted of two protein levels, 18 and 20 per cent, each with and without binlid at the 10 per cent level. Each of the two factors in the binlid column was tested with and without the antibiotics feed supplement (Afsillin Swine) at the 0.5 per cent level.

The feed and water were consumed *ad libitum*. Rations were provided in a baby pig self-feeder. The pigs were weighed every week from their 30th day of age (initial) to their 56th day, the age of weaning in the conventional method. The feed consumption in each treatment was recorded. When mortality occurred in the lot, the dead pig was weighed and the feed for that lot was weighed back and deducted from the total feed consumed to obtain accurate data for feed conversion efficiency.

Experiment II. The most efficient ration in experiment I was compared to the two other formulated starter rations containing 10 and 20 per cent Afsillin. Four litters of the same cross as those in experiment I consisting of 31 pigs were given the starter rations with skim milk. The management and care applied were the same as those described in experiment I.

Experiment III. The pigs in nine lots were compared with regards to their average gain in weight from birth to their 56th day of age. Lot I (control) with four litters of 32 baby pigs of the Berkjala x Berkshire x Berkshire and Berkjala x Berkshire x Duroc crosses weaned at the age of 56 days was compared to eight lots from experiment I with 16 litters of the same cross weaned at the age of 30 days and fed the different rations for 26 days. Health and vigor and uniformity of size of the litters were also considered.

In each of the experiments, the average gain in weight and feed conversion efficiency were considered the experimental observations in the analysis of the data according to statistical procedures described by Snedecor (1956).

The study of early weaning was based on the work of Catron *et al.* (1957) who, studying the trends in the development of digestive enzyme system in baby pigs and milk secretion of the lactating sow from birth to eight weeks (fig. 1), reported a relatively insufficient pepsin and pancreatic amylase during the first 4 weeks after birth. They have also reported that the baby pigs had an adequate

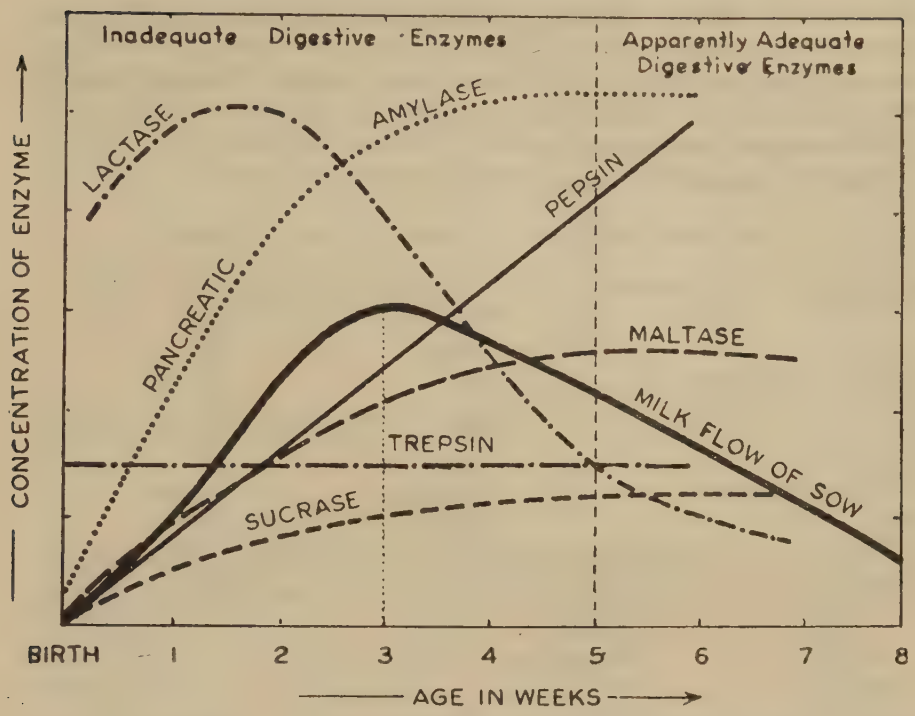

Fig. 1.—*Development of the Digestive Enzymes System in Baby Pig (from D. V. Catron* et al., 1957. *Proceedings of the Ninth Research Conference at the University of Chicago).*

source of trypsin from birth and that they followed a parallel development of this enzyme. Therefore, feeding the early weaned pigs (2-3 weeks old) with large amounts of dried skim milk would seem logical because milk protein can be digested by trypsin with little or no help from pepsin. However, this would not hold true for soya protein used as a substitute for milk protein.

In this study, soya protein was substituted for milk protein because dried skim milk was expensive in the local market. Therefore, the practice of weaning the pigs not earlier than 4-5 weeks after their birth is advantageous, because the milk secretion of the sow is at the maximum in the first 3 weeks from birth.

RESULTS AND DISCUSSION

Experiment I. From the whole test period of 26 days, the pigs fed with the different formulated starter rations with and without the antibiotic feed supplement (Afsillin), showed no significant

difference in gains. However, the highest gain in weight was obtained with the addition of 5 per cent feed supplement at 18 per cent protein without binlid (rice shorts), in the first replication (BS x BJ x BS). In general, the gains in weight with BS x BJ x DJ crossbred pigs in replication II was much lower than that in replication I using the same formulated rations (table 2).

TABLE 2.—*Composition and chemical analysis of starter rations*

INGREDIENTS	PARTS BY WEIGHT	
	I	II
Fine rice bran	10	10
Ground yellow corn	55	45
Soybean oil meal	11	11
Fish meal	11	11
Skim milk	10	20
Molasses	3	3
Ground oyster shell	(1.5%)	(1.5%)
Salt	(1%)	(1%)
Afsillin	(0.5%)	(0.5%)
TOTAL	100	100

Calculated analysis

	Per cent	
Protein	21.30	23.71
Fiber	3.06	2.87
Fat	5.43	5.09
Calcium	.95	.93
Phosphorus	.82	.83

Statistical analysis of the average gain in weights of the pigs fed the different starter rations showed suggestive interaction, although no significant differences between the protein content and the antibiotic feed supplementations in the rations was noted (table 3). The addition of 10 per cent binlid in the ration had a significant effect on the growth performance of the pigs. The best ration with 10 per cent binlid without antibiotic feed supplement was obtained in the 20 per cent protein level in both replications. Apparently, there was a poor interaction between binlid and antibiotic supplements. However, there was a synergistic effect in weight gain between protein and antibiotic feed supplements.

The most efficient feed conversion was obtained in the ration without binlid at 18 per cent level supplemented with 5.0 per cent afsillin. The average feed required to produce a kilogram gain was poor in rations without Afsillin and with binlid (table 4.). How-

TABLE 3.—*Average gain in weight of baby pigs*

ANTIBIOTIC SUPPL.	BINLID (FIBER)	PROTEIN (Per cent)	REPLICATION I (BSXBJXBS)	REPLICATION II (BSXBJXDJ)	TREATMENT SUM
0	WITH	18	1.02	1.32	2.34
		20	3.69	3.57	7.26
	WITHOUT	18	4.95	2.36	7.31
		20	5.67	1.95	7.62
0.5	WITH	18	2.86	0.60	3.46
		20	0.90	1.80	2.70
	WITHOUT	18	6.23	2.15	8.38
		20	3.35	3.43	6.78
Total			28.67	17.18	45.85

Analysis of Variance

SOURCE OF VARIANCE	D. F.	SUM OF SQUARE	M. S.
Replication	1	8.25	8.25
Antibiotic	1	0.6440	0.6440
Binlid (B)	1	12.8343	12.8343 b/
Protein (P)	1	0.5148	0.5148 a/
A x B	1	3.6005	3.6005 a/
B x P	1	1.8564	1.8564 a/
A x B x P	1	0.8883	0.8883 a/
Error	7	13.36	1.9086 a/
Total	15	42.79	

a/ Not significant.
b/ Significant.

TABLE 4.—*Average feed conversion efficiency of baby pigs*

ANTIBIOTIC SUPPL.	BINLID (FIBER)	PROTEIN (Per cent	REPLICATION 1 (BSXBJXBS)	REPLICATION II (BSXBJXD)	TREATMENT SUM
0	WITH	18	48.7	5.38	10.25
		20	3.81	1.82	5.63
	WITHOUT	18	1.36	3.02	4.38
		20	1.57	4.07	5.64
0.5	WITH	18	1.67	6.66	8.33
		20	6.44	2.66	8.70
	WITHOUT	18	1.56	2.00	3.56
		20	1.80	2.42	4.22

Analysis of Variance

SOURCE OF VARIANCE	D. F.	SUM OF SQUARE	M. S.
Replication	1	1.31	1.31
Antibiotic (A)	1	0.0743	0.0743 a/
Binlid (B)	1	14.2695	14.2695 a/
Protein (P)	1	0.3393	0.3393 a/
A x B	1	0.7181	0.7181 a/
A x P	1	1.2045	1.2045 a/
B x P	1	2.3793	2.3793 a/
A x B x P	1	1.9530	1.9530 a/
Error	7	26.76	3.8228
Total	15	9.03	

a/ Not significant.

ever, the feed conversion efficiency showed no significant differences among treatments.

Experiment II. In experiment I, it was noted that the starter ration with 18 per cent protein and 0.5 per cent antibiotic feed supplement without binlid was superior to any of the other starter rations in both gain in weight and feed conversion efficiency. This starter ration which served as control was compared to other rations containing 10 and 20 per cent skim milk as shown in tables 5 and 6. Gain in weight was higher in replication I than in replica-

TABLE 5.—*Average gain in weight of baby pigs*

SKIM MILK (*Per cent*)	PROTEIN (*Per cent*)	REPLICATION		AVERAGE a/ (*kg.*)
		I	II	
0	18	6.23	2.15	4.14
10	21	6.44	3.26	4.85
20	24	5.04	4.16	4.60

a/ No significant differences among treatments.

TABLE 6.—*Average feed conversion efficiency of baby pigs*

SKIM MILK (*Per cent*)	PROTEIN (*Per cent*)	REPLICATION		AVERAGE a/ (*kg.*)
		I	II	
0	18	1.56	2.00	1.78
10	21	1.69	2.21	1.85
20	24	1.59	1.70	1.65

a/ No significant differences among treatments.

tion II in all treatments. On the average, the pigs given the ration with 10 per cent skim milk gained 4.85 kilograms as compared to 4.60 kilograms of those given the ration with 20 per cent skim

milk and 4.19 kilograms of those belonging to the control. The feed conversion efficiency did not follow the same trend as in the gain in weight. The most efficient conversion efficiency was obtained from Replication II of the 10 per cent level. On the average, the ration with 20 per cent skim milk had the highest feed conversion efficiency of 1.65. The control had 1.78 and the 10 per cent level, 1.85. No statistical difference in both feed conversion efficiency and gain in weight was observed among treatments.

Generally, more pigs suffered from diarrhea in the 20 per cent skim milk than in the other two lots. However, it should not be concluded that the level of 20 per cent skim milk was too high for early weaned pigs because skim milk is free from fat.

Further study using higher levels of skim milk should be conducted to enable weaning earlier than 30 days. Studies on early weaning by Dyrendahl *et al.* (1958) suggested a 41.5 per cent level of skim milk.

Experiment III. In general, pigs weaned at 30 days had higher gains than those weaned at 56 days (table 7). Two starter ra-

TABLE 7.—*Average gain in weight of pigs weaned at 30 and 56 days*

REP.	WEANED AT 56 DAYS	WEANED AT 30 DAYS							
		18-0-0	18-.5-0	20-0-0	20-.5-0	18-0-B	18-.5-B	20-0-B	20-.5-B
I	5.20	8.25	7.65	8.22	7.17	6.17	5.97	6.40	5.52
II	5.63	5.20	10.81	6.80	7.21	4.00	5.12	7.28	4.13
Mean	5.41	6.72	9.23	7.51	7.19	5.08	5.54	6.84	4.82

Analysis of Variance

S.V.	D.F.	S.S.	M.S.	F-VALUE
Replication	1	1.07	1.07	
Treatment	8	32.93	4.12	2.56 a/
R x T (Error)	8	12.84	1.61	
Total	17	46.84		

a/ Significant at 5 per cent level.
H.S.D. at 5 per cent —5.02

tions with binlid (18 per cent protein without antibiotics and 20 per cent proten with antibiotics) had lower gains than lot I. The gain in weight in all the starter rations without binlid was higher than that in lot I. The 18 per cent protein with Afsillin and without binlid, compared to lot I, had a total significant difference

gain in weight of 7.57 kilograms (H.S.D.—5.02 at 5 per cent). However, the difference between lot I and the other treatments was not statistically significant.

The growth of pigs weaned at 56 days was slower after the fourth week from birth as compared to the early-weaned pigs possibly because of the decreased milk secretion of the sow after the fourth week from farrowing (Catron *et al.*, 1957).

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A COMPARATIVE STUDY OF THE FEEDING VALUE OF SIX COMMERCIAL BROILER RATIONS [1/]

A. C. CAMPOS, E. N. REYES, and R. H. GECOLEA [2/]

As listed in their respective tags, the number of ingredients used by the six feed brands vary from as few as 24 to as many as 45 ingredients.

Proximate analysis made on samples of most of the feed brands used revealed crude protein and other nutrient contents lower than the guaranteed amounts.

The best growth-promoting feed brand averaged 1286.2 grams of broilers at 10 weeks of age; the poorest, only 735.5 grams. Both brands were used in set II.

The lowest rate of mortality, 5.0 per cent, was showed by feed brand 6 of set II, but the highest, 18.6 per cent, was registered by feed brand 1 of set I.

The feed brands that produced the heaviest broilers produced the best fleshed birds.

As reflected by the poor pigmentation of the birds, brands 2 and 4 appeared deficient in pigment-bearing ingredients.

The most efficient brand in set I (brand 3) required 2.83 kilograms of feed, and in set II (brand 6), 3.19 kilograms of feed to produce a kilogram gain in weight. The corresponding figures for the least efficient brands are 3:35 kilograms for brand 1 of set I and 4.79 kilograms for brand 5 of set II.

Brand 3 of set I gave the highest returns above feed cost, followed by brands 5 and 6 of set II.

Based on the overall results of this study, it can safely be said that there is a great disparity in the feeding value of broiler rations available in the market nowadays; that the information listed in the tag attached to the feed bag cannot be considered as a reliable index of the feeding value of the feed it represents; and that, to a large extent, the profit or loss of a broiler raiser can be dictated by the brand of feed chosen.

In broiler production feed costs comprise about 70 per cent of the total cost of production.[3/] This figure indicates the relative importance of the kind and cost of feed used in determining the profit or loss from a broiler enterprise.

The production of commercial brands of broiler rations came with the growth of the broiler industry in this country. In 1960, the Bureau of Animal Industry registered 53 commercial feed

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1/ Central Experiment Station Contribution No. 2822.

2/ The authors gratefully acknowledge the assistance extended by Miss Amalia Lopez and her co-workers in the Animal Nutrition Laboratory.

3/G. C. Cook and E. M. Juergenson, "Approved Practises in Poultry Production", The Interstate Printers and Publishers, Danville, Illinois, 1955, p. 270.

companies. Although many produce broiler rations, only a few contribute to the broiler feed supply in the market. How the more popular brands compare with one another in feeding value is not known. This study, therefore, was conducted in the Poultry Research Plant, Department of Animal Husbandry, from July, 1960 to January, 1961.

MATERIALS AND METHODS

Each of the two parts in this study covered a 10-week feeding period. The first was conducted from July to October, 1960 using the three most widely sold brands of broiler feed, and the second from October, 1960 to January, 1961 using three less popular ones. The feeds used in set I were designated as brands 1, 2, and 3 and those used in set II were tagged as brands 4, 5, and 6.

In each set of experiment, 1,080 day-old Vantress-Arbor Acre cross chicks were used. These chicks were bought from the C. J. Yulo Poultry Farm in Canlubang, Calamba, Laguna. This particular blood type was selected because of its reputation as a fast grower and its excellent fleshing ability.

Both experiments followed the same experimental design and procedure. The chicks were divided at random into three lots, each replicated three times. To each replicate of every lot was assigned 120 chicks; hence, chicks in the three replicates of each lot totalled 360. All the chicks were wing-banded, vaccinated against avian pest, and individually weighed on the first day.

The ingredients used in the six feed brands tested are shown in table 1. Being a trade secret, the proportion of the ingredients used in the various feed brands was not made available. Each feed brand carries guaranteed minimum amounts of crude protein and crude fats, and maximum amounts of crude fiber and moisture content (table 1a).

Except for brands 5 and 6 which were made up of a starter mash and a finishing mash, the feed brands were represented by only one type of mash—the broiler mash. In feed brands 5 and 6, the starter mash was fed to the chicks during their first four weeks of life; thereafter the birds were given the finishing mash until they were 10 weeks of age. The broiler mash, on the other hand, was fed to the birds throughout the whole test period.

TABLE 1.—*Ingredients listed in the tags attached to the feed bags*

INGREDIENTS	FEED BRANDS					
	Set I			Set II		
	1	2	3	4	5	6
Feedstuffs:						
Corn, yellow	p [a/]	p	p	p	p	p
Corn, white	—	—	p	p	p	p
Corn, grit	—	p	p	—	p	p
Corn germ meal	p	p	p	p	p	p
Corn gluten feed	p	—	p	p	p	p
Corn hominy	—	—	—	p	—	p
Corn bran	—	p	—	—	—	—
Rice bran	p	p	p	p	p	—
Rice polishings	p	p	—	—	—	—
Wheat bran	—	—	p	—	—	p
Wheat germ	p	—	—	—	—	p
Wheat germ oil	p	—	—	—	—	—
Wheat middlings	—	p	—	p	—	—
Pollard	p	—	p	—	p	p
Brewer's dried grains	—	—	p	—	—	—
Brewer's dried yeast	p	—	p	—	—	—
Molasses	P	—	p	—	p	p
Copra meal	p	—	p	p	—	p
Fish meal	p	p	p	p	p	p
Meat scrap meal	p	p	p	p	—	p
Blood meal	—	—	—	p	p	—
Animal liver meal	p	—	—	—	—	—
Fish oil feed grade	—	—	—	p	—	—
Soybean oil meal	p	p	p	p	p	p
Ipil-ipil leaf meal	p	p	p	p	p	p
Dried whey	p	p	—	p	—	—
Dried buttermilk	p	—	—	—	—	—
Fish solubles	p	—	—	—	p	—
Dried grain fermentation solubles	p	—	—	—	—	—
Skimmilk	—	—	—	—	—	p
Bone meal	p	p	—	p	p	—
Oyster shell, ground	p	p	—	p	p	—
Salt, table	p	p	p	p	p	p
Limestone	p	p	p	—	—	p
TOTAL	24	16	18	18	16	18

Vitamin supplements:						
Vitamin A	p	p	p	p	p	p
Vitamin B12	p	—	p	p	p	p
Vitamin D	—	p	—	—	p	p
Vitamin D3 (D-activated animal sterol)	p	—	p	p	—	—
Vitamin E	—	—	p	—	p	—
Vitamin K	p	—	—	p	—	—
Folic acid	p	p	—	—	—	—
Riboflavin	p	p	p	p	p	—
Biotin	p	—	—	—	—	—
Pyridoxine	p	—	—	—	—	—
Niacin	p	p	p	p	p	p
Inositol	p	—	—	—	—	—
Choline chloride	p	p	p	—	p	—
TOTAL	11	6	7	6	7	3
Mineral supplements:						
Copper sulfate	p	—	p	—	—	—
Cobalt	p	—	—	—	—	—
Ferrous sulfate	p	—	p	—	—	—
Calcium panthothenate	p	—	p	—	p	—
Potassium iodide	p	—	p	—	—	—
Zinc sulfate	p	—	—	—	—	—
Phosphorus	—	—	p	—	—	—
Manganese sulfate	p	p	p	p	—	p
TOTAL	7	1	6	1	1	1
Other supplements:						
Methionine	p	—	p	p	p	—
Butlylated hydoxy toluene	—	—	—	p	—	—
Lecithin	p	—	—	—	—	—
Phenyl arsonic acid	—	p	—	—	—	p
Antibiotics	p	p	p	p	p	p
Coccidiostat	—	—	p	—	—	—
TOTAL	3	2	3	3	2	2
GRAND TOTAL	45	25	34	28	26	24

a/ p — present.

The feeds were bought at random from the factory and from feed agents and dealers in amounts enough to last for three weeks. During the test, three 300-gram samples of feed of each brand, taken during the early, middle, and later parts of the feeding period were submitted for proximate analysis to the Animal Nutrition

TABLE 1a.—*Guaranteed proximate analyses listed in the tags attached to the feed bags*

	FEED BRANDS							
	1	2	3	4	5		6	
	(Broiler mash)	(Broiler mash)	(Broiler mash)	(Broiler mash)	(St. mash)	(Fin. mash)	(St. mash)	(Fin. mash)
Crude protein (minimum)	21	21	21	21	21	20	20	18
Crude fat	4	4.5	8	4	3	3	5	5
Crude fiber	5	6	5	6	4	4	6	6
Moisture (maximum)	13	13	13	13	13	13	10	10

Laboratory of the Department of Animal Husbandry. Results of the analysis are shown in table 1b.

TABLE 1b.—*Proximate analysis of samples of six commercial broiler rations* a/

	FEED BRANDS							
	1	2	3	4	5		6	
	(Broiler mash)	(Broiler mash)	(Broiler mash)	(Broiler mash)	(St. mash)	(Fin. mash)	(St. mash)	(Fin. mash)
Crude protein	19.5	19.8	19.4	16.0	18.6	17.5	23.3	20.9
Crude fat	6.4	8.4	5.8	3.3	4.3	3.4	3.4	4.3
Crude fiber	5.4	4.6	5.2	6.0	3.6	6.9	2.2	4.5
Moisture	11.8	11.8	12.4	12.0	12.1	14.2	14.1	14.9

a/ Average of three samples taken during the early, middle and later parts of the feeding period.

The chicks in each set of experiments were brooded in nine identical three-tiered battery brooders with 40 birds to a tier. After four weeks, the birds were transferred to nine identical, adjacent, concrete-floor rearing pens with rice hull as litter material. The same number and size of feeding and watering troughs were used in all brooders and pens. Feed and water were provided *ad libitum*. An antibiotic preparation was added to the drinking water during the first two weeks to protect the birds from early infection by common poultry diseases.

Initial and final individual weights, bi-weekly lot weights, amount of feed consumed, rate of mortality, degrees of feathering

and fleshing, and other minor observations were recorded.

Since the two sets of tests were conducted at different months of the year and the chicks used came from different hatches, results obtained with one set cannot be considered comparable in all respects with results obtained with the other set. For this reason, data from each set were grouped separately and are discussed accordingly.

RESULTS AND DISCUSSION

Ingredients used by the six feed brands. Table 1 shows the ingredients used in the formulation of the six broiler rations. It will be noted that the sum total used, as listed in the respective tags, varies from as few as 24 to as many as 45 ingredients. With the individual feedstuffs alone, the range is 16 to 24; whereas with the supplements (vitamins, minerals and other supplements), the range is 6 to 18. These figures tend to show the great diversity in the make-up of the various broiler rations used in this study, which could reflect differences in the results obtained.

It is also interesting to note that, of the 34 feedstuffs listed, only six appear common to all feed brands. These are yellow corn, corn germ meal, fish meal, soybean oil meal, ipil-ipil leaf meal, and table salt. Corn gluten feed, rice bran, and meat scrap were listed by only five feed brands; white corn, corn grit, molasses, copra meal, bone meal, and ground oyster shells were used by only four. Vitamin A and antibiotics were the only supplements utilized by all brands. Vitamin B12, riboflavin, niacin and methionine appear comon to only five of the six brands. Except in brand 3, coccidiostat was not mentioned in the tags of the other brands. Again, these findings indicate great differences in the composition of the various rations, which could have a marked influence in their respective feeding values.

Proximate analysis of the rations. As shown in table 1a, the guaranteed minimum amounts of crude protein and crude fat of the six feed brands range from 18 to 21 per cent and 3 to 8 per cent, respectively. The guaranteed maximum amount for crude fiber was 4 to 6 per cent and for moisture, 10 to 13 per cent. However, results of sample analysis (table 1b) showed the following: For crude protein content, five feed brands were found to have lower amounts than they claim to carry. However, one brand

(No. 6) had actually more crude protein than the minimum amount it guarantees to have. With crude fat, three brands (3, 4, and 6) fell short of the guaranteed amounts, but with crude fiber, three brands (1, 3, and 5) had slightly more than the guaranteed maximum amounts. Except for the finishing mash of brand 5 and the starter and the finishing mashes of brand 6, the amount of moisture in the samples was well within the guaranteed maximum amounts. These results may be interpreted to mean that certain feed companies do not comply with the guaranteed amounts of nutrients their feed bags are supposed to contain, and/or that certain nutrients deteriorate from the time the feeds are mixed in the factory to the time they are actually fed to the birds.

Rate of growth. The average weights of the chicks at different ages were used as the basis in determining the influence of the feed on their rate of growth (table 2).

In set I, marked differences in the weights of the chicks occurred as early as the second week of the experiment, with lot 3 chicks registering the highest weight, followed by lot 2, and lastly by lot 1. This trend was consistently maintained throughout the feeding period with the weight differences between lots 1 and 2 tending to become narrow, whereas that between lots 2 and 3 showed a tendency to become wider and wider. At the end of the feeding period, lot 3 chicks averaged 1198.1 grams whereas lots 2 and 1 weighed 995.0 and 927.0 grams, respectively. Statistical treatment of the final weights of the birds showed highly significant differences between lots except that of lots 1 and 2.

In set II, birds of lots 5 and 6 had approximately the same weight from one-day to four weeks of age. After this period, however, lot 6 chicks put on weight faster than those of lot 5. At the end of the feeding period, the former averaged 1286.2 grams per bird and the latter, 1185.5 grams per bird. On the other hand, in spite of their higher average initial weight, lot 4 birds exhibited a very poor rate of growth as compared with those in the other two lots. After two, four, and six weeks of age, lot 4 birds were only about half the size of the chicks in lots 5 and 6. At the end of the test period, lot 4 birds averaged 735.5 grams, which was 450 grams lower than the weight of lot 5 and 550.7 grams lighter than that of lot 6. The differences in the final weights of the birds in the different lots were highly significant.

TABLE 2.—*Average initial and bi-weekly weights in grams of Arbor Acre x Vantress crosses given six commercial brands of broiler rations*

AGE IN WEEKS	AVERAGE WEIGHTS OF COMBINED REPLICATIONS					
	Set I (July to September, 1960)					
	Lot 1 (Brand No. 1)		Lot 2 (Brand No. 2)		Lot 3 (Brand No. 3)	
	No. of Birds	Ave. Wt.	No. of Birds	Ave. Wt.	No. of Birds	Ave. Wt.
Day-old	360	39.4	360	40.3	360	39.0
2	317	97.7	331	109.8	341	125.8
4	310	200.3	320	240.2	339	286.0
6	295	370.1	314	396.0	336	503.0
8	294	634.8	311	636.2	336	828.6
10	293	972.0	300	995.0	334	1198.1

AGE IN WEEKS	AVERAGE WEIGHTS OF COMBINED REPLICATIONS					
	Set II (October to December, 1960)					
	Lot 4 (Brand No. 4)		Lot 5 (Brand No. 5)		Lot 6 (Brand No. 6)	
	No. of Birds	Ave. Wt.	No. of Birds	Ave. Wt.	No. of Birds	Ave. Wt.
Day-old	360	37.4	360	34.7	360	35.4
2	353	96.8	347	157.2	346	150.9
4	347	227.2	346	401.0	345	402.9
6	338	359.3	333	604.2	343	685.5
8	327	503.4	331	885.7	343	945.5
10	321	735.5	331	1185.5	342	1286.2

Statistical comparison of the final weights of the birds in the two sets of experiments showed no significant difference between the two groups. This can be interpreted to mean that any difference in climatic conditions or management under which the two sets of tests were conducted did not have any marked influence on the rate of growth of the birds; that differences in weights can be attributed only to the brand of feed given. With this consideration, it is possible therefore to rank the relative growth-promoting efficiency of the six brands as follows, considering the best brand as 100 per cent efficient: 1st, brand 6, 100 per cent; 2nd, brand

Analysis of Variance of Final Weights

SOURCE OF VARIATION	D.F.	S.S.	M.S.	CFV	PROB.	H S D .05	H S D .01
Whole plot:							
Set (S)	1	631.26	631.26	0.79	$<.05$		
Replication (R)	2	900.26	450.13	0.56	$<.05$		
S x R (error a)	2	1,603.77	801.89	0.24	$<.05$		
Split plot:							
Lot (L)	2	452,519.76	226,259.88	68.15	$<.01$	95.03	132.43
L x S	2	147,664.12	73,832.06	22.24	$<.01$		
Error (b)	8	26,559.83	3,319.98				
TOTAL	17	629,879.00					

3, 92.7 per cent; 3rd, brand 5, 92.0 per cent; 4th, brand 2, 76.3 per cent; 5th, brand 1, 74.6 per cent; and 6th, brand 4, 55.8 per cent. It is surprising to know that although brand 6 had the fewest ingredients in its ration, it produced the heaviest birds. On the other hand, brand 1, which had the most ingredients listed in its tag, ranked fifth, or second to the poorest group.

Aside from the marked differences in the growth-promoting properties of the six commercial broiler feeds used in this study, this experiment showed that the number of ingredients listed in the tag that go with every bag of feed is not a reliable index of its feeding value.

Mortality. In set I, the average mortality was 18.6 per cent for lot 1; 16.7 per cent for lot 2; and 7.2 per cent for lot 3 (table 3). The figures for lots 1 and 2 were significantly higher than those for lot 3. The greatest mortality in this set occurred during the first two weeks of the study. To a great extent, this was due to the quality of chicks used and the adverse climatic conditions. Since the chicks were bought from a privately owned farm, there was no way of selecting only the healthy and vigorous individuals. Besides, the chicks came from an off-season hatch. Furthermore, the series of typhoons during the entire period of the experiment subjected the chicks to undue environmental stress at an early age, causing the weak ones to succumb in spite of all precautions taken. Nevertheless, the feed given influenced the

TABLE 3.—*Percentage mortality of Arbor Acre x Vantress crosses given six commercial brands of broiler rations*

ITEM	DATA FROM COMBINED REPLICATIONS					
	Set I (July to October, 1960)			Set II (October to December, 1960)		
	Lot 1 (Brand No. 1)	Lot 2 (Brand No. 2)	Lot 3 (Brand No.3)	Lot 4 (Brand No. 4)	Lot 5 (Brand No. 5)	Lot 6 (Brand No. 6)
Total number of chicks at start	360	360	360	360	360	360
Total number of birds after 10 wks.	293	290	334	321	331	342
Total number of birds that died	67	60	26	39	29	18
Average percentage motrality	18.6	16.7	7.2	10.8	8.0	5.0

Analysis of Variance of Mortality Rate

SOURCE OF VARIATION	D.F.	S.S.	M.S.	CFV	PROB.		HSD .05	HSD .01
Whole plot:								
Set (S)	1	149.01	149.01	26.89	< .05	> .01		
Replication (R)	2	19.43	9.72	1.75	> .05			
R x xS (eror a)	2	11.08	5.54	0.27	> .05			
Split plot:								
Lot (L)	2	200.04	100.02	4.88	< .05	> .01	7.47	
S x L	2	19.58	9.79	.48	> .05	.01		
Error (b)	8	163.96	20.50					
TOTAL	17	563.10						

rate of mortality as evidenced by the mortality pattern established during this period, which was carried over to the remaining weeks of the test.

After the second week, mortality in set I was caused principally by coccidiosis and respiratory disease. Coccidiosis, which is prevalent among birds raised on litter, caused more deaths in lots 1 and 2 than in lot 3. The presence of a coccidiostat in lot 3 ration may account for this difference. However, the coccidiostat level was apparently low or the kind used was not effective enough to completely overcome the lethal effect of coccidiosis in-

fection. To prevent excessive mortality from coccidiosis in all the lots, water medication against coccidiosis was given on the sixth and seventh week, thus minimizing the lethal effect of the disease.

In general, lot 3 birds, as indicated by their weights, were healthier than those in lots 1 and 2. This seems to be the principal reason why despite exposure to the same debilitating effect of weather conditions and disease-contaminated premises, lot 3 suffered less mortality than the other lots in the first set.

Mortality in the second set was not as high as that in the first set. This may be partly attributed to the better weather conditions that prevailed during the period covered by this portion of the study. The highest death rate registered in the second group was 10.8 per cent which occurred in lot 4; next was 8.0 per cent in lot 5; and the least was 5.0 per cent in lot 6. The differences in the death rate of the three lots, however, were not significant.

As in the first group, mortality was highest during the first two weeks in lots 5 and 6. However, in lot 4, weekly mortality was evenly distributed during the entire 10-week feeding period. The frequent mortalities in lot 4 were mostly due to a respiratory disease suspected to be nutritional roup, as indicated by the pale yellow shanks, drowsiness, and cheesy-like material under the eyelids of affected birds. In lot 5, on the other hand, the noticeably high mortality in the fifth week before medication was given was caused by coccidiosis. In general, lot 6 birds were healthier and more vigorous than birds in the other two lots, thus explaining the relatively low mortality in this lot.

As a whole, data from both sets of the test show that rate of mortality is closely related to weights of the birds. Birds which are fed better-quality rations tend not only to attain a high 10-week weight but also to incur less mortalities. In these respects, feed brands 6, 3 and 5 are considered the best in the order they are listed.

Quality of broilers produced. Table 4 shows the quality of broilers produced at the end of 10 weeks as measured by the degree of fleshing at the breast. The birds were classified into three grades: A, B and C. Grade A was for birds with full, well-fleshed breasts; Grade B for birds with medium-fleshed breasts; and Grade C for birds with sharp, thin breasts. The degree of breast fleshing was determined by feeling the breast with the

TABLE 4.—*Degree of breast fleshing of Arbor Acre x Vantress crosses given six commercial brands of broiler rations*

SET	LOT	CLASSIFICATION a/		
		% Grade A	% Grade B	% Grade C
	Brand No. 1	12.3	58.7	29.0
I	Brand No. 2	11.4	66.3	22.3
	Brand No. 3	28.7	67.7	3.6
	Brand No. 4	0.0	12.4	87.6
II	Brand No. 5	6.5	52.8	40.7
	Brand No. 6	9.1	55.3	35.6

a/ Two persons classified the birds: one for set I and another for set II.

hand.

Because the method used for determining the degree of fleshing is subjective and arbitrary, only one person was assigned to classify the birds in both sets in order that the same standard and judgment can be applied to all the birds belonging to the different lots. However, when the birds in the second set were ready for classification, the assigned classifier was not available and the work had to be done by another person. Since two persons cannot be expected to render exactly the same judgment in their classification of the birds, the rating made in the two sets of the test cannot be considered comparable. Nevertheless, the birds in the different lots within each set can still be compared.

Results in set I show that the lot fed with the best growth-promoting ration (lot 3) exhibited the greatest proportion of grades A and B birds, whereas those fed with the poorest ration (lot 1) had the most Grade C birds. Lot 2 birds were midway in their ratings. The same trend of results is shown in set II. However the birds in lot 4 of this set were so poorly fleshed that most of the birds were rated grade C, none was grade A, and only a few were grade B. These results, therefore, show that broiler rations which effect a better rate of weight gain are the rations which induce a better rate of breast fleshing.

Minor observations. The birds in both sets of the test were generally fully feathered at 10 weeks of age, except in lot 4 where 19 birds were poorly feathered, particularly at the back.

The birds in the different lots differed in degree of pigmentation of the shanks and beak. In set I, lot 3 had the most birds

with deep yellow pigments, next was lot 1 and the least was lot 2. In set II, lot 4 had more birds exhibiting light-yellow and whitish shanks and beak than either lot 5 or 6. The latter were about even in their degree of pigmentation. The deficiency in yellow pigmentation of birds in lots 2 and 4 might be attributed to a lack of pigment-bearing feedstuff in their rations, which in turn reflect a deficiency in vitamin A precursors in those rations.

Two cases of slipped tendon condition, or perosis, were observed in lot 3 of set I and two others in lot 6 of set II. This abnormality appeared in those lots with the fastest growth of birds, possibly indicating insufficiency in the rations of either manganese, biotin or choline to meet the high requirements of certain birds in these lots.

Feed consumption and returns above feed cost. Table 5 shows how the birds compare in the final analysis. In set I, lot 3 birds had the highest feed consumption but required the least amount of feed to produce a kilogram gain in weight (2.83 kilograms). On the other hand, lot 1 birds consumed the least feed but required the greatest amount of feed to produce a kilogram grain in weight (3.35 kilograms). Lot 2 birds were about midway in feed consumption and efficiency of feed utilization (3.22 kilograms).

The rations for lots 1 and 3 were almost the same in price but that for lot 2 was cheaper by about 2 centavos per kilogram. To produce a kilogram weight, it cost lot 3 only ₱0.91 worth of feed compared to ₱0.98 for lot 2 and ₱1.07 for lot 1.

In set II, lot 6 consumed the greatest amount of feed, followed by lot 5, and lot 4 consumed the least. Based on the efficiency of converting the feed consumed to gains in weight, the lot that consumed the most feed was still the most efficient. Lot 6, which was the most efficient, required 3.19 kilograms of feed to produce a kilogram gain in weight. To produce the same gain, lot 5 needed 4.79 kilograms.

The ration given to lot 5 was the cheapest, costing ₱0.296 a kilogram; that for lot 4 was ₱0.300; the most expensive was that for lot 6, costing ₱0.391 a kilogram. To produce a kilogram gain, lot 4 required ₱1.43 worth of feed, lot 5, ₱1.00 and lot 6, ₱1.25.

Broiler raisers are not interested only in the feeding value of broiler rations, but more so in the monetary returns derived through their use. If returns above feed cost are considered as the final test of the rations campared, the ration given to lot 3 is con-

TABLE 5.—*Amount of feed consumed and returns above feed cost of Arbor Acre x Vantress crosses given six commercial brands of broiler rations*

	DATA FROM COMBINED REPLICATIONS		
	Set I		
	Lot 1 (Brand No. 1)	Lot 2 (Brand No. 2)	Lot 3 (Brand No. 3)
Amount of feed consumed, kgm.	915.0	925.0	1096.0
Total cost of feed, pesos a/	292.80	281.20	352.91
Average feed consumed of each bird. gm.	3.12	3.08	3.28
Weight of broilers, kgm.	284.77	300.73	400.18
Average gain in weight of each bird, kgm.	.932	.955	1.159
Feed required for every kgm. gain, kgm.	3.35	3.22	2.83
Cost of feed to produce a kgm. gain, pesos	1.07	0.98	0.91
Returns from sales of broilers, pesos b/	569.54	601.46	800.36
Returns above feed cost from broilers, pesos	276.74	320.26	447.45

	DATA FROM COMBINED REPLICATIONS		
	Set II		
	Lot 4 (Brand No. 4)	Lot 5 (Brand No. 5)	Lot 6 (Brand No. 6)
Amount of feed consumed, kgm.	1077.4	1283.4	1365.5
Total cost of feed, pesos a/	323.22	379.89	533.91
Average feed consumed of each bird, gm.	3.35	3.88	3.99
Weight of broilers. kgm.	234.07	392.14	440.12
Average gain in weight of each bird, kgm.	.698	1.150	1.250
Feed required for every kgm. gain, kgm.	4.79	3.37	3.19
Cost of feed to produce a kgm. gain, pesos	1.43	1.00	1.25
Returns from sales of broilers, pesos b/	468.14	784.28	880.24
Returns above feed cost from broilers, pesos	144.92	404.39	346.33

a/ Cost of one kilogram of feed: brand 1, ₱0.320; brand 2, ₱0.304; brand 3. ₱0.322; brand 4, ₱0.300; brand 5. ₱0.296; and brand 6, ₱0.391.

b/ The selling price per kilogram broiler (liveweight) was ₱2.00 irrespective of the grade.

sidered the best in set I, and the ration for lot 5 in set II. For the combined sets, the ration for lot 3 is still superior, followed by the ration for lot 5. The ration for lot 6, though the most efficient in inducing growth and livability, ranks only third. These results therefore show that for a ration to be economically efficient, it should not only induce a rapid rate of growth and a slow rate of mortality but should not be very expensive.

GREEN-CORN PERFORMANCE TEST IN SWEET CORN AND IN GLUTINOUS CORN [1/]

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Nine sweet corn hybrids and 13 glutinous synthetic varieties were compared with their respective standard varieties for yield and quality in the 1959 Wet and in the 1959-1960 Dry Seasons. Sweet corn hybrids (PYS1 x PYS3) (PYS4 x HYS1) and (PYS4 x PYS3) (HYSI x PYS2) were found to have better yield than the varietal checks Philippines Yellow Sweet and Hawaii Yellow Sweet. Although (PYS3 x PYS2) (PYS4 x PYS1) was not an outstandingly good yielding hybrid it was judged to have the best eating quality. Among the glutinous varieties, Glutinous Synthetic 10, Glutinous Synthetic 5 and Mt. Province Glutinous were found high yielding and are promising sources of high-combining inbred lines. As regards to eating quality, there was no marked preference for any of the glutinous entries. The puncture and eating quality ratings indicated that the best time for harvesting sweet and glutinous corn for use as green ears are 16 to 17 and 18 to 19 days after 50 per cent silking, respectively.

When harvested at maturity, sweet and glutinous corn are distinguished from other types by a wrinkled and an ivory-like kernel, respectively. The former is controlled by a single recessive gene, *su,* at Chromosome IV and the latter by *wx,* at Chromosome IX. The ears of these types, when harvested at about the dough stage, are very suitable for use as boiled or canned corn. They are better in eating quality than the ordinary field-corn types.

For green-corn production, open-pollinated varieties are used at present, since no better seed stocks are yet available. For sweet corn, two open-pollinated varieties, Philippines Yellow Sweet and Hawaii Yellow Sweet are cultivated. Hawaii Yellow Sweet was developed from U.S. 34, a yellow sweet corn variety from Puerto Rico. Brunson and Escarlos (1956) reported that these varieties are inferior in eating quality to sweet corn hybrids from the United States. Golden Cross Bantam (P39 x P31), a single cross hybrid developed at Purdue Agricultural Experiment Station has been found to have very good eating quality and to give relatively satisfactory yield under local conditions but its component inbreds are very difficult to maintain.

For glutinous corn, four standard varieties are known to be cultivated in commercial scale, namely: (1) Central Luzon Gluti-

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1/ Central Experiment Station Contribution No. 2823.

nous, a variety commonly grown in Central Luzon; (2) Laguna Glutinous, a variety which has cylindrical ears and small kernels and is popularly grown in Laguna and vicinity; (3) Mountain Province Glutinous, a variety that was stabilized by selection from a white flint strain which was given that designation as it presumably was obtained from Mt. Province. This white flint strain was segregating for starchy and waxy endosperm, and (4) Morong Glutinous, a variety which is supposed to have originated from Morong, Rizal.

In a comparative test of these standard varieties and other provincial strains, Dosado (1956) found that Mt. Province gave the highest mean grain yield of 38.4 cavans per hectare, which was significantly higher than that of Morong, but the former was rated only second to the latter in eating quality.

With the development of new hybrids and varieties at the Central Experiment Station, a comparative test of yield and eating quality of the new types and the standard varieties is deemed necessary. Smith (1955) emphasized that in selecting for hybrids to be grown for large-scale production prolificacy, attractiveness and quality of the ears, and adaptability to local climatic conditions are some of the most important considerations. Jenkins and Sayre (1936) reported that hybrid strains were superior to open-pollinated varieties from the standpoint of improved quality and slower maturing ears. Gangstad and Snell (1948) reported that tenderness of pericarp is the primary consideration for quality sweet corn.

This study was conducted at the Central Experiment Station from May, 1959 to February, 1960 with the following objectives: (1) to compare the yield of the standard varieties to the newly produced hybrids or synthetics; (2) to determine which among the varieties and hybirds could be used as the best possible source of superior inbred lines; and (3) to determine the best stage for harvesting green corn hybrid and varieties.

MATERIALS AND METHODS

For sweet corn, nine double-cross hybrids and two open-pollinated varieties were entered in the test. The entries were as follows:

1. (PYS1 x PYS3) (PYS4 x PYS2)
2. (PYS1 x HYS1) (PYS4 x PYS2)

3. (PYS1 x PYS3) (PYS4 x HYS1)
4. (PYS1 x HYS1) (PYS4 x PYS3)
5. (PYS1 x PYS3) (HYS1 x PYS2)
6. (PYS4 x PYS1) (HYS1 x PYS2)
7. (PYS4 x PYS3) (HYS1 x PYS2)
8. (PYS3 x PYS2) (PYS4 x PYS1)
9. (HYS1 x PYS3) (PYS4 x PYS1)
10. Philippines Yellow Sweet
11. Hawaii Yellow Sweet

Inbreds PYS1, PYS2, PYS3 nad PYS4 were extracted from Philippines Yellow Sweet, and HYS1, from Hawaii, Yellow Sweet. These inbreds were judged high-combining in a top cross test in 1957-58 dry season. 2/

Glutinous corn materials were composed of four open-pollinated varieties and 14 synthetics. They were as follows:

Designation	*Pedigree*
Glutinous Synthetic 1	(A207 x A209) (A207 x A214)—# —#
Glutinous Synthetic 2	(A207 x A214) (A207 x A212)—# —#
Glutinous Synthetic 3	(A207 x A214) (A213 x A212)—# —#
Glutinous Synthetic 4	(A212 x A209) (A207 x A209)—# —#
Glutinous Synthetic 5	(A212 x A209) (A207 x A212)—# —#
Glutinous Synthetic 6	(A212 x A209) (A214 x A212)—# —#
Glutinous Synthetic 7	(A214 x A212) (A207 x A212)—# —#
Glutinous Synthetic 8	(A201 x A203) (A207 x A212)—# —#
Glutinous Synthetic 9	(A201 x A203) (A207 x A214)—# —#
Glutinous Synthetic 10	(A201 x A203) (A214 x A212)—# —#
Glutinous Synthetic 11	(A207 x A209) (A201 x A203)—# —#
Glutinous Synthetic 12	(A207 x A209) (A214 x A212)—# —#
Glutinous Synthetic 13	(A212 x A209) (A201 x A203)—# —#
Morong White Glutinous	
Central Luzon White Glutinous	
Laguna White Glutinous	
Mountain Prov. White Glutinous	

The synthetic varieties used in the study were advanced generations of glutinous hybrids. The parental inbred lines of the hybrids were developed from top-cross selected white flint lines which were segregating for the waxy gene. The inbreds A201 and

2/ Unpublished data from experiments conducted by O. Q. Ballesteros of the Division of Plant Breeding.

A203 were developed from College White Flint and inbreds A207, A209, A212, and A214, from Bicol White Flint. A203 was a high-combining line. The inbred lines, however, unfortunately got lost because of poor storage facilities in 1955. Glutinous Synthetics 1 to 7, inclusive, are three-line synthetics; Glutinous Synthetics 8 to 14 four-line synthetics. The symbol # was used to indicate the number of sib-pollinations.

Although the sweet corn entries were tested in a separate group from the glutinous entries, the methods used in the yield and organoleptic tests for the two groups were very similar. Both groups were tested in the 1959 Wet Season and in the 1959-60 dry season. In the sweet corn group the same entries were used on both seasons except for Hawaii Yellow Sweet which was substituted for the hybrid (PYS1 x PYS3) (PYS4 x PYS2) in the dry season. For the glutinous entries, second generation sibbed seeds were used in the wet season and the third generation sibbed seeds in the dry season.

The simple randomized complete-block design was used. All had 4 replications except the wet-season test of sweet corn which had only 3. Each plot consisted of two rows, five meters long. spaced one meter apart. Each row was planted to 10 hills at intervals of 50 centimeters. Three to four seeds were dropped to a hill and each hill was thinned to two plants three weeks later.

Ammophos (16-20-0), at the rate of 200 kg. per hectare, was applied at planting. Four weeks later, the plants were side-dressed with ammonium sulfate (20-0-0) at the rate of 150 kg. per hectare.

The experimental area was cultivated, weeded, and sprayed whenever necessary. Pest and disease injuries were reduced to the minimum by spraying twice with Gesarol E-25 at the rate of 18 ml. and parzate at the rate of 9 grams per gallon of water. First spraying was done three weeks after planting and the second, just before flowering. A plot was considered germinated when 50 per cent of the plants have emerged from the ground and silked, and when 50 per cent of the ears have some of their silks emerged. Days to silking was computed as the number of days from date of emergence to date of silking.

Other agronomic characters that were observed before harvesting were: (1) root lodging or the reclining of the plant 45° or more from the vertical; (2) stalk lodging, or stalk-breaking below the upper most ear; (3) plant height, measured from the ground

to the tip of the tassel, (4) ear height, measured from the ground to the node of the highest ear; (5) pests and diseases; and (6) weight of stubbles just after harvesting.

The number of missing hills and stand count of each plot were recorded just before harvesting the ears at 18 to 19 days after silking. First and second ears were harvested separately. The ears were husked and classified into marketable and non-marketable ears. The latter consisted of those that were very short, those that were poorly filled, those that were too young for use as green corn, and those that were damaged considerably by pests and diseases so as to make them unfit for the market. All the rest were considered marketable. The marketable and non-marketable ears were then counted and weighed separately. From the marketable ears, ear length, ear diameter, length of blank tip, average kernel rows, straightness of rows, and kernel size and color were noted.

For testing pericarp tenderness and eating quality, a separate planting was made. The entries were planted at different dates to synchronize silking. Just before silking, the ears were bagged. Immediately after the silks have emerged the ears were hand-pollinated and the date of pollination indicated. These hand-pollinated ears were then tested for eating quality and pericarp tenderness at ages of 12 to 13, 14 15, 16 to 17, and 18 to 19 days after pollination for sweet corn and 14 to 15, 16 to 17, 18 to 19, and 20 to 21 days after silking for glutinous corn.

The tenderness of the pericarp was measured with the use of a puncturing device described by Dosado (1956). Three kernels each from the butt, middle, and tip of each ear were punctured. Two ears were used for each age under each entry. The average of the puncture values from the two ears was computed to represent the index at the different ear ages.

The organoleptic evaluation of quality was made on four ears for each ear age under each entry. The ears with husk still on were cooked at the same time in one container. A panel of 10 evaluated the eating quality of the cooked ears.

RESULTS AND DISCUSSION

Marketable-ear yield. Green corn for the market, either cooked or uncooked is usually sold by the number. Consequently, the grower who intends to channel his produce through this outlet

is concerned with the number of ears produced per unit area in addition to the relative size of the individual ears. On the other hand, the grower who intends to sell his produce to processors would want to grow a hybrid or variety which gives high tonnage per unit area, since processors buy ear corn by weight. Hence, in this study yield is expressed in terms of both weight and number of marketable ears per hectare.

The yield of marketable ears of sweet and glutinous corn in weight and in number together with their respective percentages of the total ear yield in the 1959 Wet and 1959-60 Dry Seasons are presened in tables 1 and 2. The C.V.'s means and H.S.D. values are also given. Differences in yield between entries were usually significant at the 5 per cent level, with some occasionally reaching the 1 per cent level. (PYS1 v PYS3) (PYS4 x HYS1) was the highest yielder among the sweet corn entries. It significantly outyielded the check, Philippines Yellow Sweet, at the 1 per cent level in both seasons. Among the glutinous entries, Synthetic 10 gave the highest yield. Although its yield was only a little higher (non-significant) than that of the variety Mt. Province, it significantly outyielded the varieties Morong and Laguna and five other synthetics. Generally, those entries that did well in the wet season were also the best in the dry season. There was a striking similarity in the yield rankings of the entries in both seasons. This was specially so in the glutinous group in which the entry season interaction was absent. A few entries, of course, deviated from the general behavior. Most striking of them is (HYS1 x PYS3) (PYS4 x PYS1) which was outstanding only in the wet season in weight based yield. This could be an example of a hybrid that is very specific in its adaptability.

The relative size of the marketable and non-marketable ears can be estimated by comparing the weight-based and number-based percentages. If both are about the same in magnitude, the two ear groups are about the same in average weights, and probably in size. If one is heavier than the other, the percentage by weight and by number would differ correspondingly. Results in this study showed that weight-based percentage is always higher than number-based percentage indicating that the non-marketable ears were, on the average, smaller than the marketable ones. This can be expected since one of the criteria for classifying ears under the non-marketable group was inadequacy of size.

TABLE 1. —*Marketable- ear yield of eleven sweet corn double crosses and varieties in the 1959 Wet and 1959-60 Dry Season*

ENTRY	1959 WET SEASON				1959-60 DRY SEASON			
	WEIGHT		NUMBER		WEIGHT		NUMBER	
	Yield	Per Cent	Yield	Per Cent	Yield	Per Cent	Yield	Per Cent
	tons/ha.		*thousands/ha.*		*tons/ha.*		*thousands/ha.*	
1. (PYS1 x PYS3) (PYS4 x HYS1)	7.83	90.90	52.17	82.65	5.80	98.80	39.11	97.47
2. (PYS4 x PYS3) (HYS1 x PYS2)	7.40	96.62	43.04	89.92	5.18	99.60	37.58	99.38
3. (PYS1 x PYS3) (HYS1 x PYS2)	7.31	94.18	48.39	87.26	5.21	97.20	40.10	96.43
4. (PYS4 x PYS1) (HYS1 x PYS2)	7.23	92.21	47.45	83.61	4.74	92.47	36.33	87.62
5. (PYS1 x HYS1) (PYS4 x PYS3)	7.29	92.74	34.01	83.65	4.39	93.04	33.18	90.71
6. (PYS1 x HYS1) (PYS4 x PYS2)	6.54	91.55	44.43	79.79	4.96	94.94	35.33	92.60
7. (HYS1 x PYS3) (PYS4 x PYS1)	7.47	94.94	48.00	87.97	3.70	88.92	31.61	85.48
8. (PYS3 x PYS2) (PYS4 x PYS1)	6.16	95.57	36.12	88.91	3.86	87.14	32.12	83.16
9. Philippines Yellow Sweet	4.63	86.73	31.66	74.97	3.86	91.42	33.55	87.00
10. (PYS1 x PYS3) (PYS4 x PYS2) [a]	6.08	94.29	42.98	87.80	—	—	—	—
11. Hawaii Yellow Sweet [b]	—	—	—	—	4.34	89.46	33.15	84.58
MEAN	6.79	92.97	42.82	84.65	4.60	93.30	35.23	90.44
C. V.	12.4		14.6		11.3		7.8	
H.S.D. 0.05	2.45		18.34		1.27		6.72	
0.01	3.00		—		1.51		8.04	

[a] Included only in the 1959 Wet Season Test.
[b] Included only in the 1959-60 Dry Season Test.

TABLE 2.—*Marketable-ear yield of eighteen glutinous corn varieties (Synthetics and open-pollinated) in the 1959 Wet and 1959-60 Dry Seasons*

ENTRY	1959 WET SEASON				1959-60 DRY SEASON			
	WEIGHT		NUMBER		WEIGHT		NUMBER	
	Yield	Per Cent	Yield	Per Cent	Yield	Per Cent	Yield	Per Cent
	tons/ha.		*thousands/ha.*		*tons/ha.*		*thousands/ha.*	
Glu. Syn. 10	4.02	84.0	29.4	78.4	4.17	94.6	37.5	93.8
Mt Province	3.43	77.1	25.4	67.0	4.21	91.2	35.3	88.6
Glu. Syn. 5	3.16	79.7	26.0	66.2	4.27	91.8	36.0	90.0
9	3.23	79.7	29.7	78.9	3.77	94.0	35.5	90.9
8	2.92	75.0	25.9	66.3	4.06	91.7	35.2	88.1
6	3.12	79.7	26.0	67.0	3.59	87.0	31.3	80.0
1	2.96	73.4	24.4	66.3	3.65	87.0	33.2	83.7
4	2.82	76.6	25.7	68.9	3.79	90.5	34.0	85.6
Central Luzon	2.91	80.4	26.9	72.2	3.64	93.0	36.3	91.8
Glu. Syn. 12	2.84	78.3	24.4	64.4	3.84	80.0	29.8	73.8
14	3.14	79.2	25.9	66.7	3.18	85.0	31.0	78.0
2	3.10	73.0	24.8	62.3	2.94	80.9	28.0	72.1
7	2.89	76.6	24.6	63.5	3.14	85.1	32.2	82.6
Morong	2.78	75.3	25.5	64.2	3.24	86.2	31.9	81.4
Glu. Syn. 13	2.92	71.0	25.0	63.0	2.86	83.4	29.7	77.0
Laguna	2.72	77.3	28.2	71.6	3.02	89.2	32.8	82.0
Glu. Syn. 11	2.12	79.0	21.2	55.0	3.25	86.4	32.5	78.1
3	2.64	78.7	22.9	58.8	2.67	76.7	26.0	66.6
MEAN	2.98		25.6		3.50		32.7	
C. V.	18.5		16.0		17.7		13.8	
H.S.D. 0.05	1.40		—		1.62		11.7	
0.01	—		—		1.86		13.5	

The yield of marketable ears of an entry is dependent on at least two factors: the percentage of marketable ears and the total ear yield. It is the total of the sum and the product of the two that determines marketable ear yield. When both are high, very high yields are obtained. Results in this experiment show that the total yield was more important than percentage marketable ears in determining yield rankings. Correlation coefficient between rankings in total yield and rankings in marketable ear yield is much higher than the correlation coefficient between rankings in marketable ear yield and rankings in percentage marketable ears.

As mentioned previously, number yield with due regard to very conspicuous difference in ear size and weight is an important consideration in choosing the hybrid or variety to grow. This point is specially important in the glutinous group since the ear weight of different entries varied considerably so that some entries that were relatively high in number-based yield had low weight-based yield, and vice-versa. In cases such as this, the grower should be guided

by the fact that when differences in ear weights are not big enough to be visually discernible, that variety or hybrid that yields more marketable ears is more profitable, regardless of the behavior of their weight-based yield. A very good illustration of this point is the case of glutinous Synthetic 4 and Central Luzon White Glutinous. The former was better by .02 tons in weight-based yield but the latter gave 1,700 more ears per hectare. This condition resulted because the ears of synthetic 4 were on the average 6 grams heavier than the ears of Central Luzon White Glutinous. If this difference is not big enough to be noticed by the buyers, then Central Luzon White Glutinous will be more profitable when the ears will be sold by the number.

The sweet corn entries and the glutinous entries were tested in separate groups with no common check. Statistically, comparisons between entries belonging to different groups are unjustified. For practical purposes, however, it seems that some general comparisons could be made since the two experimental groups were planted at about the same time and the experimental areas used were adjacent to each other. When such a comparison was made, two striking differences were very apparent. First, the yield levels of the sweet corn entries were higher than those of the glutinous entries. Second, the mean yield of the sweet corn entries in the wet season was almost twice that in the dry season. On the other hand, the mean yield of the glutinous entries was almost the same in both seasons, the difference being in favor of the dry season mean yield. These differences should be expected since the sweet corn entries are mostly F1 hybrids while the glutinous entries are mostly advanced generation synthetics. As such, the former should be, on the average, more superior in yield and more sensitive to seasonal variations than the latter.

The C.V. of ear yields for the glutinous group was always higher than the corresponding C.V. in the sweet corn group (tables 1 and 2). Decidedly, the glutinous entries were more genetically variable, being synthetics and open-pollinated varieties. Furthermore, there were more entries in the glutinous group than in the sweet corn group. It should be realized that the efficiency of any field design is expected to decrease as the number of entries are increased. It is very interesting to note, also, that the C.V.'s for weight-based yield were much higher than their corresponding C.V.'s

for number-based yield except in the wet season test of the sweet corn group. This general behavior should be expected since weight-based yield is much more easily affected by environmental factors than number-based yield. It can easily be visualized that slight differences in fertility levels could affect the weight of ears produced but it would take greater differences in levels of productivity to be able to produce two ears per plant from those that ordinarily produce only one. Also, error resulting from uncorrected difference in moisture content would increase the C.V. of weight-based yield but not the C.V. of number-based yield. The one exception to the general trend, however, should be enough to remind one that there are also factors that are likely to make the C.V. of number-based yield larger than that of weight-based yield.

Pericarp Tenderness

Culpepper and Magoon (1927) reported that among the factors affecting quality of green ears, the degree of tenderness and toughness of the pericarp are the most important. They further stated that although mechanical puncture is subject to some degree of error, it furnishes a reliable index of the probable tenderness of cut corn. The puncture index at a varying number of days after pollination in both wet and dry season for the sweet and glutinous corn entries are presented in tables 3 and 4, respectively. For the glutinous group puncture readings at 20-21 days after pollination were not included because almost all the readings exceeded the maximum toughness that can be measured by the puncture tester used. Although more than one ear was used in the puncture test, there was essentially no replication. In the analysis of variance, each season was analyzed separately using the entry x ear age interaction as the error. All H.S.D. values presented in tables 3 and 4 should be used only for comparing entry mean and age mean, not for making comparisons among puncture indices of different varieties at different ear ages. The HSD for the latter would certainly be larger than either the HSD for ear age or for entry. It seems that the few samples taken in this experiment and the precisions of the puncture tester used do not warrant the making of such comparisons.

Significant differences in pericarp tenderness were observed among entries and among ear ages in both groups. For sweet corn,

TABLE 3.—*Puncture-test values of eleven sweet corn hybrids and varieties in the 1959 Wet and 1959-60 Dry Seasons*

ENTRY	a/ SEASON	DAYS AFTER POLLINATION				MEAN
		12-13	14-15	16-17	18-19	
1. (PYS1 x HYS1) (PYS4 x PYS2)	A	146	200	206	288	210
	B	155	201	223	249	207
2. (PYS1 x PYS3) (PYS4 x HYS1)	A	175	207	217	240	210
	B	126	144	201	209	170
3. (PYS1 x HYS1) (PYS4 x PYS3)	A	124	146	155	267	173
	B	123	183	205	229	185
4. (PYS1 x PYS3) (HYS1 x PYS2)	A	137	179	196	254	192
	B	180	221	226	234	215
5. (PSY4 x PYS1) (HYS1 x PYS2)	A	126	179	193	264	190
	B	205	206	209	268	222
6. (PYS4 x PYS3) (HYS1 x PYS2)	A	154	159	225	266	201
	B	117	151	200	242	178
7. HYS1 x PYS3) (PYS4 x PYS1)	A	136	174	210	235	189
	B	156	177	212	229	194
8. (PYS3 x PYS2) (PYS4 x PYS1)	A	114	159	171	227	168
	B	124	194	238	279	209
9. Philippines Yellow Sweet	A	136	209	237	281	216
	B	224	263	269	316	268
10. Hawaii Yellow Sweet	A	173	205	212	224	204
	B	198	222	236	286	236
MEAN	A	142	182	202	255	
	B	161	196	222	254	
H.S.D. 0.5	A					44.8
	B					44.8
0.01	A					—
	B					49.2

a/
A—Wet Season, 1959.
B — Dry Season, 1959-60.

the variety Philippines Yellow Sweet had the toughest pericarp, confirming the findings of Brunson and Escarlos (1956) that Hawaii Yellow Sweet has a more tender pericarp than Philippines Yellow Sweet. In the wet season, only (PYS3 x PYS2) (PYS4 x PYS1) showed a significantly more tender pericarp than Philippines Yellow Sweet. In the dry season all the hybrids had more tender pericarp than Philippines Yellow Sweet but only three of them were significantly better than Hawaii Yellow Sweet. These three were also the best hybrids in the dry season. Among the glutinous entries, the puncture indices from season to season were so variable that it was very difficult to pinpoint the entry with a definitely tender pericarp.

TABLE 4.—*Puncture-test values of eighteen glutinous corn varieties (synthetic and open-pollinated) at varying number of days often pollination in the 1959 Wet and 1959-60 Dry Seasons*

ENTRIES	NUMBER OF DAYS AFTER POLLINATION						MEAN	
	14-15		16-17		18-19			
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Glu. Syn. 1	107	101	141	227	280	270	176	199
Glu. Syn. 2	112	130	136	225	350	310	199	222
Glu. Syn. 3	103	85	152	128	390	239	215	151
Glu. Syn. 4	123	79	183	207	400	233	235	173
Glu. Syn. 5	105	100	213	220	396	376	238	232
Glu. Syn. 6	117	107	139	268	350	377	202	251
Glu. Syn. 7	109	197	179	276	400	395	229	289
Glu. Syn. 8	118	119	168	220	400	383	229	241
Glu. Syn. 9	117	247	152	259	270	399	180	302
Glu. Syn. 10	114	93	194	263	400	269	236	208
Glu. Syn. 11	112	118	199	216	400	388	237	241
Glu.. Syn. 12	110	105	202	200	400	263	237	189
Glu. Syn. 13	114	102	173	210	332	399	206	237
Glu. Syn. 14	114	267	223	384	399	398	245	350
Morong	108	109	181	208	360	236	216	184
Laguna	102	116	189	234	357	360	216	237
Central Luzon	114	109	222	242	400	280	245	210
Mt. Province	110	199	152	213	400	312	221	241
MEAN	112	132	178	233	371	327		

		Entry	Ear Age
H.S.D. (Wet)	0.05	77	21
	0.01	ns	26
(Dry)	0.05	118	26
	0.01	137	40

The fact that the pericarp resistance to mechanical puncture increases with age (Bailey and Bailey, 1938) was well illustrated by the ear age means in both groups at both seasons. For every two-day interval, there was a consistent increase of about 35 and 100 puncture units for sweet and glutinous corn, respectively. Between the ages of 14 to 20 days after pollination, glutinous kernels increased in toughness more rapidly than sweet corn kernels, resulting in glutinous corn being tougher than sweet corn kernels at the 18-to-19 day stage. At the 14-to-15 day stage, however, the glutinous kernels had an average puncture index of 122 units while the sweet corn entries had an average of 189 units. At 14

days after pollination, therefore, the glutinous entries had softer pericarp than sweet corn entries but 6 days later the reverse was true. If tenderness is an indication of the stage of development of the pericarp, the above data would seem to indicate that pericarp development in glutinous corn starts slowly at the early stages, gradually increasing in rate until glutinous corn becomes tougher at the later ear age. This indication could be further verified by studying pericarp tenderness immediately after pollination.

Eating Quality

While the puncture tester is expected to provide a measure of pericarp tenderness, the eating-quality test provides an overall measure of desirability of an entry. Tables 5 and 6 present the results of the eating quality test for the sweet and glutinous corn entries, respectively. The ratings for each ear age under each entry are

TABLE 5.—*Mean quality ratings* [a/] *of the sweet corn double crosses and varieties*

ENTRY	DAYS AFTER POLLINATION				MEAN
	12-13	14-15	16-17	18-19	
1. (PYS1 x HYS1) (PYS4 x PYS2)	3.08	2.65	2.52	1.97	2.56
2. (PYS1 x PYS3) (PYS4 x HYS1)	2.65	3.80	2.98	3.38	3.20
3. (PYS1 x HYS1) (PYS4 x PYS3)	4.08	3.68	2.87	2.55	3.29
4. (PYS1 x PYS3) (HYS1 x PYS2)	2.12	2.83	2.30	3.05	2.58
5. (PYS4 x PYS1) (HYS1 x PYS2)	2.51	2.51	2.37	3.02	2.60
6. (PYS4 x PYS3) (HYS1 x PYS2)	3.23	3.51	2.55	3.40	3.17
7. (HYS1 x PYS3) (PYS4 x PYS1)	3.38	3.05	3.15	3.25	3.21
8. (PYS3 x PYS2) (PYS4 x PYS1)	1.29	3.00	3.00	2.50	2.45
9. Philippines Yellow Sweet	4.43	3.57	5.00	4.75	4.44
10. Hawaii Yellow Sweet	3.40	3.60	2.00	3.40	3.10
MEAN	3.02	3.22	2.87	3.13	

[a/] 1 — good, 3 — fair, 5 — poor.

means based on cardinal values, that is, 1 or 3 or 5 provided by the taste-test panel. The ratings would indicate good, fair, and poor eating quality, respectively. A mean quality rating of 2.00 would indicate a quality between good and fair; 4.00, between fair

TABLE 6.—*Quality ratings a/ of glutinous corn varieties (Synthetic and open-pollinated) in the 1959 Wet and 1959-60 Dry Seasons*

ENTRIES	DAYS AFTER POLLINATION AND SEASON								MEAN	
	14-15		16-17		18-19		20-21			
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
Glu.. Syn. 1	2.5	6.5	3.5	4.0	4.0	1.5	3.5	4.0	3.4	4.0
Glu. Syn. 2	1.5	4.5	3.5	5.5	3.5	1.5	3.5	4.5	3.2	4.0
Glu. Syn. 3	1.5	5.5	2.5	3.5	3.0	2.0	4.0	4.0	2.8	3.8
Glu. Syn. 4	3.0	3.0	2.0	3.5	2.5	4.5	3.5	5.0	2.8	4.0
Glu. Syn. 5	3.0	3.0	2.5	4.5	3.0	2.5	4.5	6.0	3.0	4.0
Glu. Syn. 6	5.0	6.0	3.0	4.5	3.0	2.0	1.5	3.5	3.1	4.0
Glu. Syn. 7	4.0	4.5	3.5	2.5	5.0	3.5	4.0	5.5	4.1	4.0
Glu. Syn. 8	3.5	6.0	4.5	3.0	2.5	1.5	2.5	6.0	3.2	4.1
Glu. Syn. 9	2.5	5.0	3.5	3.0	3.2	1.5	4.0	6.5	3.3	4.0
Glu. Syn. 10	1.5	5.5	4.0	4.0	5.0	2.0	3.0	4.5	3.4	4.0
Glu. Syn. 11	2.5	5.5	3.0	3.0	1.5	2.0	4.5	5.5	2.9	4.0
Glu. Syn. 12	2.5	5.0	3.5	3.0	2.5	3.5	4.5	4.5	3.2	4.0
Glu. Syn. 13	2.5	7.0	3.5	3.0	2.5	2.0	4.5	4.0	3.1	4.0
Glu. Syn. 14	4.0	5.5	2.0	4.0	4.0	1.0	4.5	5.5	3.6	4.0
Morong	4.5	4.0	3.2	4.0	1.5	3.5	3.0	4.5	3.0	4.0
Laguna	4.0	7.0	3.0	5.0	5.0	3.0	5.0	1.0	4.2	4.0
Central Luzon	4.0	6.0	3.0	1.5	3.2	3.0	5.0	4.5	3.8	3.8
Mt. Province	3.5	6.0	3.0	2.5	5.0	3.0	3.0	3.5	3.6	3.8
Mean	3.1	5.3	3.2	3.5	3.3	2.4	3.8	4.6	3.4	4.0

a/ Wet Season: 1 — good, 3 — fair, 5 — poor.
Dry Season: 1 — Very good, 3 — good. 5 — fair, 7 — poor.

and poor. As in the puncture test, the values for each ear age showed a considerable degree of inconsistency. Some entries, for example, at successive ear ages, fluctuated from better than fair, to much less than fair, back to fair, and to less than fair again. Such data would lead one to believe that green corn kernels have a repeating cycle of desirability as the kernels mature. This, of course, does not seem logical or probable. Such fluctuations most probably are the result of the small sample size in relation to the inherently difficult task of evaluating a very subjective character as eating quality. While not much importance can be attached to the individual values, certainly the means for each entry and the means for each ear age had enough samples for determining general desirability.

The sweet corn entries can be grouped into three relative quality groups: less desirable, desirable, and more desirable. Philippines Yellow Sweet (4.44) was alone by itself in the less desirable group. Hawaii Yellow Sweet (3.10) fell under the desirable group together with four hybrids with mean quality ratings of 3.17, 3.20, 3.20, and 3.29, respectively. The four remaining hybrids which could be called more desirable have mean quality ratings of 2.45, 2.56, 2.58, and 2.60, respectively. It might be worth pointing out here that (PYS3 x PYS2) (PYS4 x PYS1) which had significantly more tender pericarp than Hawaii Yellow Sweet in both seasons had the best eating quality rating of 2.45 in this test. Similarly, the other three hybrids under the more desirable group had puncture test values in both seasons that indicated that hey had a more tender pericarp than Philippines Yellow Sweet. The importance in this organoleptic test of the relative tenderness of the pericarp, which certainly is only one of the several factors or components of good eating quality, cannot be fully ascertained. It was comforting at the very least that the hybrids that rated well in eating quality did not have the toughest pericarp.

For the glutinous entries, general preference for certain entries are harder to point out. The range in rating from the "best" to the "poorest" was not large enough to exceed considerably the variability between individual values. This certainly should make one hesitate in making conclusions.

The means for each ear age are more reliable since they were computed from a much larger sample. Furthermore, the variation from one age to another is more consistent and more logical.

For sweet corn, there was a general preference for ears that were 16 to 17 days old while for glutinous corn, for ears at the age of 18 to 19 days. Most probably, these ages are the right ones for harvesting sweet and glutinous corn as green ears.

Other Agronomic Characters

Data on plant and ear characters for sweet and glutinous corn are presened in tables 7 and 8 respectively. Since the differences from season to season were small, the figure presented are means for the two season, except for those entries that were tested only in one season. Number of days from emergence to silking for the sweet corn entries ranged from 47 to 50 days for glutinous corn, 45 to 48 days, except for Central Luzon which silked as early as 40 days after emergence.

The stubble weight, taken immediately after harvest, reflects the profuseness of vegetative growth and the degree of usefulness of an entry in silage production. Data on ear characters would indicate to some extent the visual appearance of the ears. It should be realized that the market value of a corn ear will depend to a large extent on its appeal to the eyes of the buyers.

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TABLE 7.—*Agronomic characters, other than yield, of sweet corn double cross and varieties*

ENTRIES	Days to Silking	Height Plant	Ear Height	Root Lodging	Stubbles	Weight Per Ear (gms.)	Ear Length	Ear diameter	Length Black Tip	Average Kernel Rows
		cm.	*cm.*		*ton/ha.*	*gm.*				
1. (PYS1 x PYS3) (PYS4 x PYS2)	49	218	97	14.5	16.7	140	15.8	3.9	—	12—14
2. (PYS1 x HYS1) (PYS4 x PYS2)	48	214	88	17.1	16.3	143	15.9	3.8	3.1	14
3. (PYS1 x PYS3) (PYS4 x HYS1)	48	212	85	20.2	12.2	146	15.9	3.8	2.2	14—16
4. (PYS1 x HYS1) (PYS4 x PYS3)	49	223	84	22.0	16.3	147	15.8	3.9	2.2	12—14
5. (PYS1 x PYS3) (HYS1 x PYS2)	47	216	87	20.5	15.2	141	15.9	3.8	3.6	14
6. (PYS4 x PYS1) (HYS1 x PYS2)	49	214	84	15.8	16.1	147	16.0	3.9	2.1	12—14
7. (PYS4 x PYS3) (HYS1 v PYS2)	49	225	85	11.8	15.4	153	16.3	3.9	3.1	14
8. (HYS1 x PYS3) (PYS4 x PYS1)	48	220	84	17.5	14.9	137	15.0	3.8	3.2	14
9. (PYS3 x PYS2) (PYS4 x PYS1)	49	204	80	5.9	14.1	144	15.6	3.8	2.5	12—14
10. Philippines Yellow Sweet	49	203	63	21.4	13.6	131	15.8	3.8	2.1	12—14
11. Hawaii Yellow Sweet	50	188	52	—	—	130	15.8	3.8	2.6	12—14
M e a n	49	212	81	16.7	15.7	142	15.8	3.8	2.7	

a/ Included only in 1959 Wet Season trial.
b/ Included only in 1959-60 dry season trial.

TABLE 8.—*Agronomic characters, other than yield, of glutinous corn varieties (Synthetic and open pollinated)*

ENTRIES	Days Silking to	Plant Height	Ear Height	Stubble Weight	Weight Per Ear	Ear Length	Ear diameter	Lgth. black tip	Average kernel rows	Ear worm damage	Downy Mildew
		cm.	*cm.*	*tons/ha*	*cm.*	*cm.*	*cm.*	*cm.*		*per cent*	*per cent*
Glu. Syn. 1	46	217	91	12.5	117	16	3.0	3.0	14	24.7	28.9
Glu. Syn. 2	46	204	83	10.9	115	16	3.0	2.9	14—16	21.6	78.6
Glu. Syn. 3	46	215	90	15.6	110	16	2.9	3.0	14	14.4	48.6
Glu. Syn. 4	45	210	90	16.6	111	15	2.9	2.5	14	12.3	51.3
Glu. Syn. 5	46	222	98	16.8	119	17	3.0	2.8	14	12.4	46.6
Glu. Syn. 6	46	219	91	16.8	118	15	3.0	2.3	14	19.7	69.4
Glu. Syn. 7	45	213	91	16.5	108	16	2.9	2.9	14	21.2	75.7
Glu. Syn. 8	46	223	98	22.9	114	16	3.2	2.9	14	12.2	54.8
Glu. Syn. 9	46	216	90	11.8	106	16	2.9	3.2	14—16	19.3	62.2
Glu. Syn. 10	46	235	101	17.5	124	16	3.1	3.2	16	17.5	59.5
Glu. Syn. 11	46	218	89	16.9	103	16	2.7	2.7	14	23.9	66.0
Glu. Syn. 12	47	215	92	14.2	107	16	2.7	2.8	12—14	19.3	67.6
Glu. Syn. 13	46	215	92	14.2	107	16	2.7	2.8	12—14	19.3	67.6
Glu. Syn. 14	48	221	95	21.5	111	15	3.0	2.8	14	22.9	59.5
Morong	47	220	94	15.0	109	15	2.9	3.0	12—14	11.0	63.6
Laguna	40	201	84	10.0	94	16	2.8	2.5	14	14.5	37.8
Central Luzon	45	21	92	13.8	104	16	1.5	3.1	14	21.0	65.9
Mt. Province	46	224	91	9.2	127	16	3.2	3.0	14	20.7	16.7
Mean	46	218	92	15.3	112	16	28.7	28.7		17.8	58.1

NOTE: CYTOLOGY OF PHILIPPINE PLANTS. VII. NEPHELIUM LAPPACEUM LINN.

The fruit tree Rambutan (*Nepphelium lappaceum* Linn.) has been steadily gaining popularity in the Philippine fruit market. This species was formerly found in Palawan, Jolo and Basilan [1/] but lately its cultivation has been extended to most parts of the country.

Sporocytes of rambutan were collected from several trees in the orchard of the Department of Agronomy for the cytological studies.

OBSERVATIONS

The gametic chromosome number of *Nephelium lappaceum* Linn. is 11 (fig. 1 and 2). The meiotic behavior was normal and

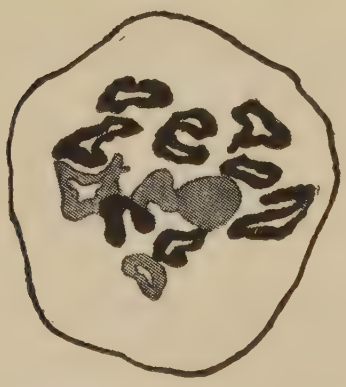


Fig. 1.—*Camera lucida drawing of a rambutan soporocyte at diakinesis showing* 11 *pairs of chromosomes.*

one chromosome had always been observed to be attached to the nucleolus. Chromosome knobs were evidently numerous in the aporocytes observed (fig. 3). A detailed chromosome analysis at

1/ W. H. Brown, "Uuseful plants of the Philippines." Vol. 2, 1954, pp. 3-66-367.

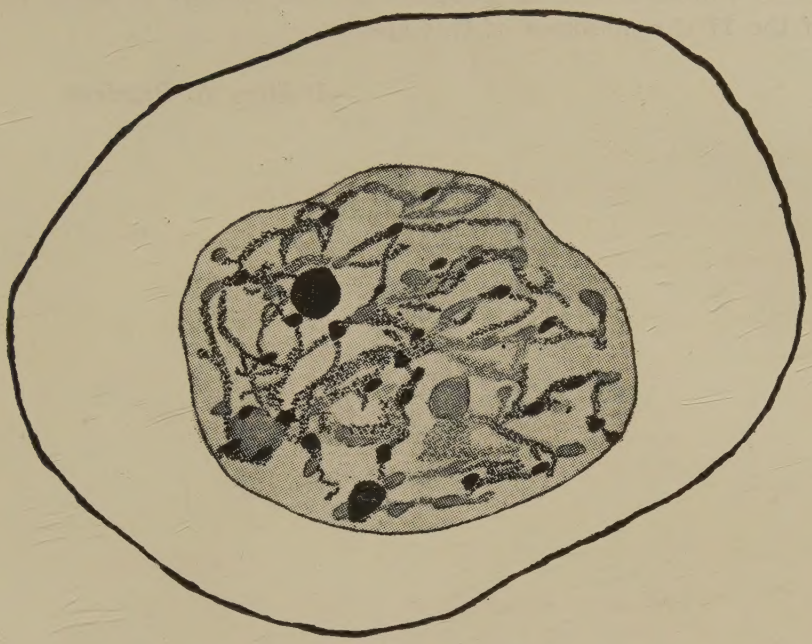


Fig. 2.—*Camera lucida drawing of PMC of rambutan at pachynema showing the numerous chromosome knobs.*

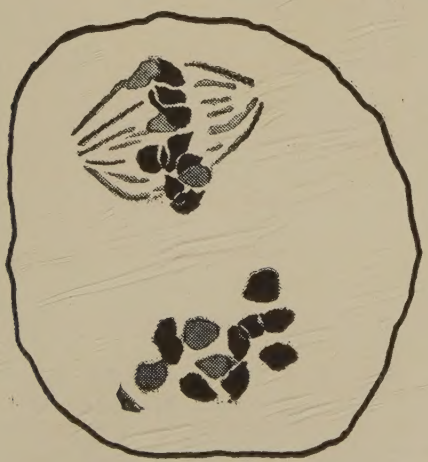
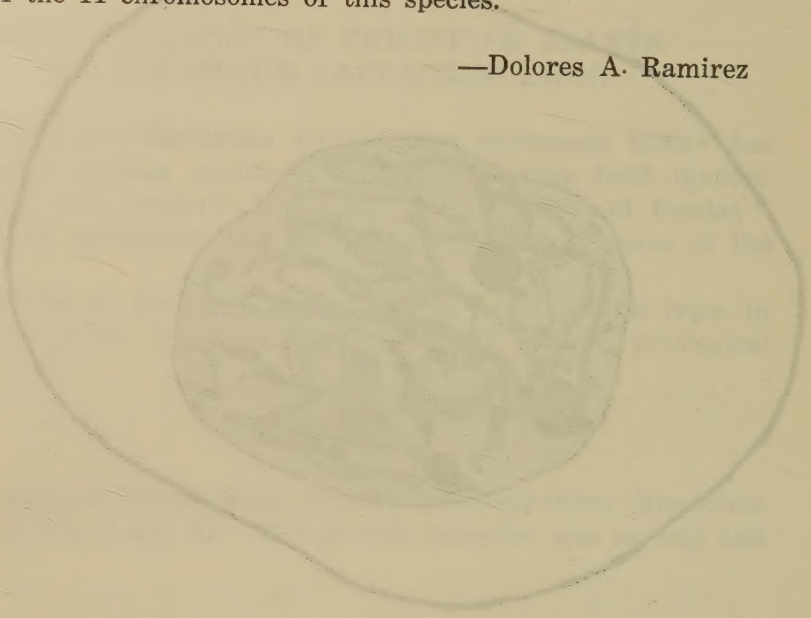
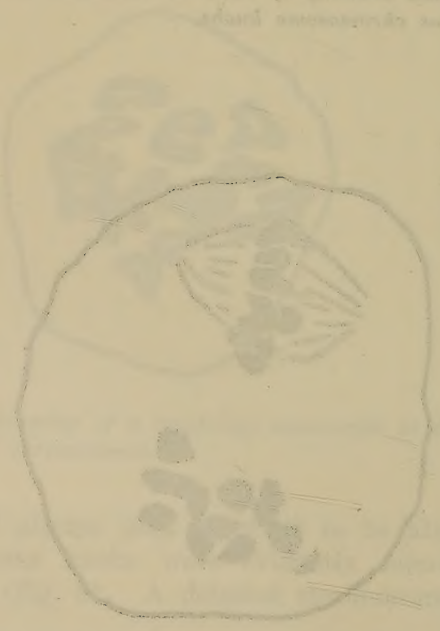


Fig. 3.—*Camera lucida drawing of rambutan PMC at the metaphase 2 stage.*

pachynema will ascertain the locations and the number of knobs in each of the 11 chromosomes of this species.

—Dolores A. Ramirez





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